technique correctly. However, this itself is not the actual meditative state. Shear and Jevning (1999) point to the traditional markers of reaching absorption into pure consciousness, which modern neuroscience research verifies: temporary spontaneous cessation of breath; decrease in hepatic and renal blood flow with simultaneous increase in cerebral blood flow; EEG synchrony; and the cessation of all internal experiences except for consciousness itself.

Ineffability or ungraspability of pure consciousness is a constant theme in both Buddhist and Hindu literature. Yet, one knows when one has this experience because consciousness knows itself: Its most fundamental property is that it is conscious of being conscious; it is a self-knowing awareness (Rangdrol, 1990). Only afterward can one think about it and conceptually classify it. However, as seen in the following section on non-dual awareness, pure consciousness can be present with all experiencing and thinking—but the thoughts or images and symbols are not identical to the realization of pure consciousness.

The well-known Katz-Forman debate exemplifies the constructivist objection—the details of which are beyond the scope of this dissertation. Briefly, the essence of Katz's argument (1978) is that all experiences are cultural constructs occurring in the context of the culture to which the experiencer belongs. Thus, there can be no "pure consciousness" common to everyone. Furthermore, all experiences are propositional in nature, built from verbal concepts, memories, re-cognitions, and constrained by beliefs, expectations, symbols, and rituals. Forman (1989, 1998) agrees that there is a constructed and conditioned level of experience; however, pure consciousness has no empirical phenomenal content of any kind, so it cannot be a construct. He points to the obvious fact that consciousness precedes linguistic constructs: To learn a language, one first must be conscious. To a certain extent, this debate is similar to the above-mentioned traditional argument about non-conceptuality.

Summary

The conclusion of the above analysis is that pure consciousness is the experience of consciousness without content, and that it is different from the states of consciousness such as waking, dreaming and deep sleep, as well as from the altered states of consciousness. In that sense it is regarded in Asian nondual philosophies as the consciousness-in- itself or, as the nature of consciousness.

Nondual Awareness

In this section I will research further the topic of nondual awareness, and in particular the objections to the existence of nondual awareness and to the similarity of nondual awareness and space.

Arguments Against Nondual Awareness in Tibetan Buddhism.

A number of traditions within Buddhism hold that one's cognitions, emotions and perceptions must stop in order to realize pure consciousness (Cozort, 1986). Another view is that this rule applies only to the earlier stages of one’s meditation practice, and that after clearly realizing pure consciousness, one begins to integrate it with daily experiences (Kongtrul, 1996). However, since nondual awareness, by definition, encompasses all experiences, including all states and functions of consciousness, it seems logical that it may not be necessary to first isolate it from experiencing in order to realize it. This becomes evident when one realizes that awareness is space-like and pervading throughout one's body and environment (Chagme, 1998).

The Dalai Lama summarizes this idea as follows:

> According to the more recent traditions of Tibetan Buddhism, …in order for this fundamental innate mind of clear light to become fully evident, it is necessary first of all for the coarser levels of ordinary mind, caught up with thoughts and concepts, to be harnessed by yogas, such as the yoga of vital energies, pranayoga, or the yoga of inner heat, tummo. On the basis of these yogic practices, and in the wake of those adventitious thought patterns of ordinary mind being harnessed and purified, the fundamental innate mind of clear light-'mind' in that sense-becomes fully evident.
>
> From the point of view of Dzogchen, the understanding is that the adventitious level of mind, which is caught up with concepts and thoughts, is by its very nature permeated by pure awareness. …the student experiences the nature that permeates them [concepts and thoughts] as the fundamental innate mind of clear light, expressing itself in all its nakedness. That is the principle by which practice proceeds on the path of Dzogchen (2004, p. 33).

Aside from the methodological arguments that question whether pure consciousness can be realized accurately within experience, Buddhist philosophers sometimes advance an argument against nondual awareness along these lines: If nondual awareness is the ultimate nature of consciousness outside of the cause-and-effect chain, then it is not empty in the sense of emptiness being the dependent arising, and this would contradict the central tenet of Buddhism that all things are empty of self-nature because they arise in dependence on causes and conditions (Dalai Lama, 2004). The answer given to this argument is that nondual awareness is permanent in the sense that its continuum is unbroken and endless, but since the present moment of nondual awareness arises from the previous moment of nondual awareness, it is also dependently arising. This answer satisfies the notion of the momentary-ness of consciousness, which is aimed at uprooting the tendency to reify nondual awareness into independently existing absolute. However, while this argument, preserves the nondual character of ultimate reality and of our experience of it, there is no way to deny that both pure consciousness and nondual awareness are unconditioned and unchanging, and in that sense could be called an absolute when compared to the transitory experiences. Thus, even though the holistic experience of reality is nondual in nature, there are still two distinct sides to it: the absolute and the relative. This argument then appears to be about two different things: how it is versus what it is. The answer to one is not the answer to the other, and this is a point of frequent confusion in Buddhism.

A more subtle argument against the existence of nondual awareness has to do with the nature of duality: If nondual awareness embraces all phenomena and functions of consciousness, as stated both in Dzogchen texts and in the Mahamudra notion of the "co-emergence" of awareness and experience (Namgyal, 2001), then what exactly constitutes nonduality? It cannot be a mere non-conceptuality as some Zen teachings claim. Transpersonal psychologists argue that duality is the result of the activation of defense mechanisms by which unwanted and threatening aspects of one's experience are blocked out (Almaas, 1996; Blackstone, 1997).

One can understand the nature of duality by examining the function of basic unconsciousness or alaya vijnana, which obscures self-recognition of awareness. The first characteristic of duality is that the awareness does not know itself directly. It is a dimming, so to speak, of awareness' brightness (Guenther, 1984). This dimming is followed by selecting an object, the foreground against the background, in such a way that the field of experience becomes fragmented into subject and object. Thus, duality is the result of basic ignorance (the failure of self-recognition) and the subsequent over-focusing which engenders excessive conceptualization (Trangu, 2002). Nondual awareness, on the other hand, differs from the ordinary dualistic mind in that it is without this division into subject and object (Sherab & Dongyal, 1998). In terms of cognitive psychology, it could be said that in nondual awareness the foreground and the background are seamlessly integrated.

Arguments Against Nondual Awareness as Space in Tibetan Buddhism.

Tibetan Buddhists sometime advance an argument against nondual awareness being like space as follows: Space is an object of experience, something on which a subject who is meditating focuses, and therefore it is a conceptual construct indicative of the dualistic mode of knowing, rather than being the nondual awareness (Khartar Rinpoche, personal communication, February 16, 2005). In answering this argument one could say: It is true that ordinarily one experiences space in this dualistic manner, as an object of one's cognition that is outside and different from oneself. However, the space of nondual awareness is not an object or something separate from oneself. This space, undivided between the inside and outside of one's body, is identical with one's awareness and is, in fact, one's true self. This identity is realized when one "rests within the expanse of the central channel," as indicated by statements such as: "During meditative equipoise, every phenomenon is of equal taste in having the essential non-referentiality of suchness, since, to illustrate this with an example, the experience of these is completely equivalent to the experience of the center of open space" (Gyamtso, 2004, p. 157). While outside the scope of this dissertation, Tibetan Buddhism, (Guenther, 1976) and more recently Transpersonal Psychology (Blackstone, 1997), extensively explore the significance of the central channel with regard to the realization of nondual awareness.

A classic Dzogchen text "Self-liberation through Seeing with Naked Awareness" also rebuts the argument by describing nonduality or enlightenment as the intrinsic awareness that realizes the space of phenomena (Sanks. *Dharmadhatu*) (Reynolds, 1989). The same text then goes a step further in underscoring the phenomenological identity of nondual awareness and space when it admonishes followers of the Mahamudra style of meditation not to fall into the error of separating awareness and space.

Nondual Awareness in Advaita Vedanta

Union of absolute and relative. Of all the modern scholars and commentators on the classical Upanishads, Radhakrishnan (1995) addresses the issue of nondual awareness most clearly. He arrives at the idea of the union of absolute and relative, of pure consciousness and phenomenal experience, which he sees as simultaneous transcendence and immanence, through the reconciliation of the impersonal, absolutistic nonduality of Shankara with the theistic qualified monism of Ramanuja. He finds the roots of this idea in the Rg Veda's hymn of creation, which he believes suggests the distinction between Brahman and Ishvara, the universal pure consciousness and the cosmic creative mind (Radhakrishnan, 1995). In his approach, there are influences of both Sri Aurobindo's evolution of consciousness philosophy (Aurobindo, 1996) and attempts to validate Vedanta by finding similarities in it with Christianity, as when Radhakrishnan labels Brahman as "Godhead" – using Meister Eckhart's term.

Because there is an ongoing emphasis in Upanishad philosophy on both ultimate reality being transcendent absolute pure consciousness which is different from all phenomena, and on ultimate reality being identical with everything that exists, these apparent discrepancies have been a source of confusion and discord over many centuries. Radhakrishnan resolves this central issue by resorting to an intensely theistic interpretation. He reformulates the fourfold structure of the Universe and human experience found in the Mandukya Upanishad as: *Brahman*—the Absolute; *Ishvara*—God as Creative Power; *Hiranyagarbha*—God immanent in the World, or Word-Spirit; and *Viraj*— the material World. He states:

> The Eternal in his transcendent form as Brahman or, cosmic being as Ishvara, does not arrive at immortality. It is the individual who is subject to ignorance who rises to self-knowledge. The self-expression of the Supreme through the individuals will continue until it is completed. The Divine possesses always its unity, and Its aim in the cosmic process is to possess it in an infinite experience through many conscious selves. So long as we are subject to ignorance, we stand away from God and are immersed in our limited egos. When we rise to self-knowledge, we are taken up into the Divine being and become aware of the Infinite, Universal Consciousness in which we live. (Radhakrishnan, 1995, p.79)

Again we see here the influence of Aurobindo, as well as of Ramanuja's philosophy of qualified monism. Radhakrishnan states clearly that "we should see all existence in Self and the Self in all existence" (1995, p. 130), yet he designates the relative in theistic terms. He does not accept that human life is an experience of impermanent, interdependent processes occurring against the background of pure consciousness. Rather he holds that there must be both a soul as an essential being integrating various processes and God that guides their unfolding.

The question here is whether his approach, and theism in general, is a result of personifying and reifying a state of consciousness, and whether in the long run this actually represents an obstacle to realizing the unity that is its goal. On the other hand, one may ask whether an impersonal approach constitutes a psychological depersonalization and dissociation. Radhakrishnan seems to understand clearly what realization of oneness or nonduality is, and that it has two different aspects to it – the absolute and the relative, whose relationship is the simultaneous transcendence and immanence. However, this view can also be understood differently. Since the nature of ultimate reality and the nondual realization that reveals it is entirely non-conceptual, the transcendent is not some other being different from oneself, even if that other is God. Rather, when abiding in nondual awareness, the same pure consciousness that one experiences as being transcendent to all phenomena is also experienced as being immanent in them. As such, it is entirely beyond mental grasping or labeling, as both Nagarjuna and Gaudapada point out.

This way of describing the realization of nondual awareness also follows the realization method laid out in the earliest Upanishads. First, one distinguishes pure consciousness from all other aspects of experiencing through the method of negation (Sansk. neti, neti). Thereafter, the identity of pure consciousness, as Brahman or Atman, with all things is realized (Deutsch, 1973). It is from this position that we can best understand the seemingly contradictory statements, which on one hand distinguish Atman as different from all phenomena and, on the other hand, equate it with everything that exists.

The significance of simultaneous transcendence and immanence is that it implies that in order for one to directly realize or experience oneness or nonduality, pure consciousness must function as nondual awareness during phenomenal experiencing.

Now, one could argue that describing realization as simultaneous transcendence and immanence is indicative of duality, since for something to be either transcendent or immanent, there must be something else to which the entity is transcendent or immanent—thus, a duality. To answer this, one could say that all words like relative and absolute, and immanent and transcendent, are simply manners of speaking, and not to be confused with the reality they point to. Duality arises as the result of the reification of subject and object as being separate and essentially different. In the actual experience of realization, the two are inseparable and are of the same quality of being-awareness-bliss (Maharshi, 2000).

Arguments against nondual awareness as space in Advaita Vedanta. The most frequent objections to equating nondual awareness with space in Advaita Vedanta are based on strict vivartavada interpretation, according to which, as previously mentioned, pure consciousness is homogenous, atemporal, unlocalizable and cause-less, and cannot be realized as long as there is experience of any kind occurring (S. Atmaroopananda, personal communication, May 12, 2004). These objections find support in certain verses of the Upanishads, such this one from the Brihadaranyaka Upanishad: "This indemonstrable and constant being can be realized as one only. The Self is taintless, beyond space, unborn, great, and constant" (Radhakrishnan, 1995, p. 278).

Other objections concern the nature of space, seeing it as a mere negative or the absence of things, as in certain Buddhist doctrines. Shankara argues against this view in his commentaries on the Brahma Sutra of Badarayana (Vireshvarananda, 1993). The Brahma Sutra is a series of cryptic verses composed, according to traditional accounts, by Badarayana sometime in the fifth century B.C.E., as a mnemonic device for the Vedanta teachers in their arguments against the competing Indian philosophies of the time. It is likely, as with many other classical Vedanta texts, that a number of verses in the Brahma Sutra were added at some later point in time as debates over the specific viewpoints developed. The extreme brevity of the verses, which originally allowed for easier remembering and also protected their secrecy so that only those directly initiated could understand them, has in later centuries led to considerable challenges for their interpreters.

According to Shankara, the various metaphors for space mentioned in the Brahma Sutra refer to Brahman, the universal all-encompassing pure consciousness. For example, he says, "That which is called space is the revealer of all forms and names." Shankara claims that this verse describes Brahman because it is preceded by the verse: "All this is Brahman" (Vireshvarananda, 1993, p. 47). Here, as in many of his interpretations, he stretches the implied meaning of the verses to justify his viewpoint. Yet, as often noted (Isayeva, 1993), Shankara achieves what is arguably the most elegant and coherent philosophical system of either East or West.

Darling (1987), who appears to have been a protégé of the late Alex Wayman, presents a careful exposition of how the major teachers of Vedanta (Shankara, Ramanuja and Madhava) misinterpreted Buddhism in their critiques of it. Of course, what he fails to mention is that the reverse is true as well. Among the verses of the Brahma Sutra that Darling selects for refutation is one of the sutras on space—that according to him reads: "And in case of space, because of non-distinction" (1987, p. 245). This sutra represents Badarayana's argument against the teachings of space being impermanent and a mere absence, found in the Sautrantika and Sarvastivada schools of early Buddhism. Shankara, Ramanuja and Madhava comment on this verse and disagree with Buddhists, advocating for the permanence of space and its identity with Brahman. While the formal logic of these arguments is not the present concern, it is important to note that Advaita Vedanta regards space itself, and the similarity of space and Brahman, as an ongoing permanent feature of ultimate reality.

Brooks (1968) also sees the difficulty with Vedanta's use of the idea of space, most obviously with the ambiguity of its translations, as mentioned before. More importantly though, Brooks revisits Shankara's argument against the notion that space is a mere absence:

> Indians made no real distinction between the concept of the very rarefied substance (ether) and a purely relational concept (space). Shankara, in fact, while arguing against the Buddhist realists, even claims that space (akasha) cannot be merely a negative thing (the absence of objects), for one has to be able to determine where this absence is—and that requires a positive determination, therefore a positive entity (1968, p. 36).

Here Brooks misunderstands the space referred to in the Brahma Sutra and in the Upanishads as being a conceptual level of space, the space that is cognized as an object, thus implying distance and a relationship. Rather, the use of space in these Vedantic sources indicates the realization of the sameness of space inside and outside, as an all-pervading nondual awareness. The translation of space as ether is an unfortunate anachronism and a mistake, as noted before.

Interestingly, just a few pages later, Brooks arrives at the simultaneous transcendence and immanence of pure consciousness, by examining the metaphysical dimension of space:

> In the final analysis, then, all material objects, including the vehicles of human consciousness, are composed of akasha *(space)*. It must be emphasized, however, that akasha *(space)* itself doesn't alter its basic nature in the process. All that occurs is its molding into differing forms which are given different names (1968, p. 38).

From a larger perspective, one could say that the emphasis on the existence of space in Vedanta, or on the lack of its inherent existence in Buddhism, is only a matter of pedagogical approach. There is no difference in the experience of the actual space dimension of nondual awareness that can be realized through either of these traditions.

Summary

The conclusion of the above research is that nondual awareness is pure consciousness occurring with experience, and that it is the space-like context of experiencing. The next section of this chapter will examine what are the neural correlates of nondual awareness, and whether the neural correlates of space in the posterior parietal cortex mediate nondual awareness in conjunction with areas in the pre-frontal cortex.

Neural Correlates of Pure Consciousness and Nondual Awareness

This section presents the research on the question: “Do the neural correlates of space in the posterior parietal cortex meditate nondual awareness, in conjunction with medial and dorso-lateral areas of the pre-frontal cortex?”

As mentioned in the introduction, the significance of modern scientific research on meditation is that it can facilitate the overall goal of neuroscience to find the neural correlate of consciousness. It can also prove certain theories of Asian nondual philosophies, which have been contentious for centuries – through more or less unambiguous brain measurements.

However a question can be raised whether pure consciousness and nondual awareness described in the Asian philosophies are the same as those that are being tested by the scientists. In defining the difference between lucidity and witnessing during dreaming, Travis (2003) states that in witnessing, there is a quality of a steady separate self who is silently observing but not influencing the dream, whereas during lucid dreaming, the subject feels involved in the dream and does not experience himself as separate. He sees this as a sign of meta-cognition during lucid dreaming and points to studies by Gackenbach (1985) that showed that lucid dreamers have a higher capacity for observing their daily experiences, as well. It is important to note, however, that pure consciousness is not meta-cognition, because it is not a conceptual process of thinking about something or even reflecting on the process of thinking. Rather, it is consciousness resting in its own nature.

Wallace (2004) argues against the claim of TM researchers that their subjects experience pure consciousness. In accordance with the Yogachara philosophy of Buddhism, he claims that the presence of substrate consciousness, which underlies discrete states of consciousness, is not yet the evidence of pure consciousness. According to him, the substrate (Sansk. Alayavijnana) functions as the indeterminate background from which either the dualistic or pure consciousness emerges. The difference can be ascribed to the degree of non-conceptuality. However, there can be a complete mental quiescence without self-recognition of consciousness. Wallace (2004) claims that encountering pure consciousness, as when one attains lucidity during deep sleep without experiencing anything but awareness and the awareness is recognized, is not yet pure consciousness because this recognition is a conceptual activity, as in: "I am now aware." Conversely, pure consciousness is self-knowing and does not require a thought process. This direct knowing is then manifested as an extra luminosity and a vividness of awareness.

However, the matter is a bit more subtle, because pure consciousness can also occur in the presence of other functions of mind, such as thoughts, so that one can be in pure consciousness and simultaneously think: "I am aware." The proof that TM subjects are realizing pure consciousness, and not just the substrate, are the alpha-theta wave bursts. For his part, Travis does not make the distinction as to whether pure consciousness is self-recognized or not.

D'Aquili & Newberg (1999, 2002) appear to conflate pure consciousness with nondual awareness. They describe the loss of "all sense of discrete being" and the remaining “undifferentiated consciousness”. These are descriptions of the states of absorption and isolation of consciousness from experiencing. However, the question remains as to whether these states indicate that pure consciousness has become self-recognized, or whether these are various states of absorption experienced on the way to realizing pure consciousness – for the descriptions could easily refer to the states of energetic merging that frequently occur during meditation, but which are not the realization of either pure consciousness or nondual awareness. As pointed out earlier, nondual awareness is not a state of disorientation and loss of psychological boundaries. Rather, nondual awareness does not fragment the field of experience into subject and object.

Brain at Rest

As mentioned previously in the methodology section, one of the central issues is the neural activity of the brain at rest. Because the brain at rest generates noise in fMRI scans, it may not be entirely appropriate to attribute all of the activations obtained in fMRI meditation studies to meditative states of consciousness such as nondual awareness. Others have noticed this problem for some time (Zarahn, Aguirre & D’Esposito, 1997), and so patterns of brain activity at rest are now being examined using different methods of data analysis (Fransson, 2004).

One could logically assume that the brain at rest shows decreased activity across all areas, since when one is resting, the brain seems to be less active, if not inactive. Surprisingly, Reichle, MacLeod, Snyder et al. (2001) found a pattern of continuous higher activation in certain brain areas when at rest than when the brain is performing a task. This suggests "…the existence of an organized, baseline default mode of brain function that is suspended during specific goal-directed behaviors" (Raichle et al., 2001, p. 676). The areas of higher activation are chiefly the posterior cingulate gyrus and its connections to prefrontal areas. In addition, the researchers state that the high activity in the medial frontal and medial parietal regions represents the unified perspective of the organism relative to its environment, and thus is a constituent of a self. This brings into question whether such activations are found during nondual awareness, since, as shown in a previous literature review section, some main features of nondual awareness are deactivation of focused task-oriented attention and the lack of fragmentation of experience between the self and the environment.

Gusnard, Abdulkak, Shulman et al. (2001), found that the dorsal medial prefrontal cortex shows increased activity during the rest state consistent with self-referential mental activity, while decrease in the activity of the ventral medial prefrontal correlates with attention-demanding tasks related to processing emotions. They conclude that the default state of the brain at rest consists of both self-referential and emotional processing activity subserved by the medial prefrontal cortex. This finding may be relevant to the study of nondual awareness, which as discussed before, is a way of resting in being.

Laufs, Krakow, Sterzer et al. (2003), found oscillations in the alpha range which they correlate with inattention during the rest state, and oscillations in the beta range which they believe correlate with spontaneous cognitive operations during conscious rest.

Finally, Fransson (2004), contends that there are actually two networks that operate when the brain is at rest: one that is self-referential and consists of the medial prefrontal cortex and posterior parietal cortex, and another that is involved in monitoring external space and extroverted processes and possibly consists of areas in the somatosensory, motor, and visual extrastriatal areas, the insula, and the parietal and lateral prefrontal cortexes. These two networks are mutually exclusive and alternate between each other. Fransson hypothesizes that this alternating between the two is the state of the brain at rest. A new study by Raichle and colleagues appears to confirm this (Fox et al., 2005).

Building on the above-mentioned studies of the resting state of consciousness, Lou and colleagues (2004) propose that the medial parietal cortex is the seat of the autobiographical self, and that this area is activated with the medial prefrontal cortex and posterior cingulate gyrus during the brain at rest, because the resting state is a self-monitoring process involving autobiographical self and episodic memory.

As mentioned previously, in nondual meditation, one realizes internal and external space to be the one and the same space. This implies that there is no necessity to shift between self-referential and external-centered processing. This important point will be further explored in the next section.

As previously pointed out in the methodology section, the problem with using the resting state as a control state, against which activations during nondual awareness are measured, is that the resting brain state of someone who has years of meditation experience is quite different from the resting brain state of a "normal" individual. Meditation leads to an overall decrease in metabolic rate and a general decrease in conceptual activity of the mind, and specifically, to a decrease in self-preoccupations—in other words, to a decrease of thinking related to the biographical self. The question that arises here, relevant to the study of nondual awareness, is whether these areas should be de-afferented during nondual awareness, since one is not centered or abiding in the biographical self.

When a meditator experienced in meditation on nondual awareness rests, that is, when he or she is not meditating and is thus presumably not in nondual awareness, one could speculate that she or he is abiding in alaya vijnana or the substrate consciousness (Wallace, 2004). Thus, there is not much conceptual or emotional activity occurring in his brain. From there, the shift to nondual awareness is a very small shift into awareness knowing itself directly.

The nature of the brain at rest is a considerable issue for research into neural correlates of nondual awareness, because nondual awareness once realized cannot be unrealized, so that even when the realized meditator is resting, there is some background signature of realization present. In an unpublished study conducted at Rutgers University using an experienced meditator, there was an overall decrease in BOLD signal responsiveness, even during eyes-open tasks. This is to be expected because one trains to rest in nondual awareness in such a way that nondual awareness becomes one's ongoing background state of consciousness.

Neural Correlates of Pure Consciousness

Since in the previous section of the analysis it has been determined that nondual awareness is pure consciousness operating with experience, in order to research whether the neural correlates of space mediate nondual awareness, the neural correlates of pure consciousness will be examined first, and then the neural correlates of nondual awareness and of the space in meditation.

Recognizing pure consciousness as a valid topic of research in the field of neuroscience has been a difficult and relatively recent development (Varela & Shear, 2002). Progress on this issue is hampered by the general orientation of Western philosophy and science toward relativism and functionalism, and, as mentioned previously, by the excessive focus on the contents of consciousness (Shear & Jevning, 1997; Taylor, 2002, 2003). Research into pure consciousness is also made more challenging by the difficulty of accurately understanding what pure consciousness is. For example, Taylor correctly differentiates pure consciousness from the contents of consciousness, yet draws a conclusion that pure consciousness is a state where attention is attending to itself (2002). As noted earlier in the section on Vedanta, attention too is a function of consciousness, not consciousness itself.

As mentioned in the review of literature, EEG studies of meditation focus on several characteristics of the general meditative state of consciousness: the increase in alpha waves associated with relaxation; the strong frontal bursts of theta waves associated with peaceful self-awareness; bursts of high frequency beta and gamma waves in the 20-40 Hz range associated with intense concentration or periods of ecstasy; the de-coupling of subcortical structures from the cortex; and hemispheric synchronization - a coherence of brain waves across the left-right and anterior-posterior areas of the brain (Murphy & Donovan, 1999). The sequential progression of EEG changes during the course of a meditation session have been summarized as follows: Initially, there is an increase in alpha amplitude posteriorly, and then there is a slowing of alpha frequencies and a forward spread into frontal areas. This is followed by an increase in theta activity in the range of 6-7 Hz, first in intermittent bursts and then with increasing regularity until rhythmic theta trains become synchronized in both anterior and posterior EEG leads. Then, in deep meditation, bursts of high beta waves appear in the range of 20 Hz and above (Andresen, 2000).

To better appreciate what might be occurring in meditating brain in terms of electrical activity detectable by EEG, especially as it relates to pure consciousness and to nondual awareness, it is necessary to discuss a few background facts regarding the neuronal binding and synchrony.

Neuronal Binding and Synchrony

One of the main issues in neuroscience is the problem of "binding" – that is, how to explain the fact that the brain organizes a great deal of disparate information into a coherent experience. For example, when I see my wife in her car pulling into our driveway, the shape of the car, its color, its movement, the sound of the engine and my wife's face are all coded in different parts of my brain, yet I have one unified experience. This issue is even more pronounced in nondual awareness, which is characterized by the extraordinary coherence and unity of experience. Engel & Singer (2001b) summarize the issue of binding:

> 1. Consciousness results from a cooperative process in a highly distributed network, and is not attributable to a single brain structure; 2. binding is highly relevant for the neural correlate of consciousness; 3. only coherent activity, resulting from the operation of binding mechanism, could become functionally salient, causally efficacious and globally available, and, thus could lead to the emergence of conscious mental states and their respective behavioral manifestations. The critical point is that binding may not only serve for achieving the 'unity consciousness' but, first of all, for 'gating' the access to awareness and, hence, for turning subconscious information into conscious mental content (pp. 21-22).

How is this binding accomplished in the brain? The serial transmission of signals from neuron to neuron through axonal firing is far too slow to account for this unity of experience. The mechanism proposed is neuronal synchrony, the temporary synchronization of neuronal discharges. Some postulate that all cognitive processes in the brain, such as perception, emotion, action, attention, imagination, abstract thinking, and others, depend on the coordination of widely distributed neural networks – producing a temporarily unified global brain activity

– and that their integration is neuronal synchrony, the firing of distant neurons at the same frequency (Engel et al., 2001a&b; Llinas, Ribary, Contreras & Pedroarena, 1998; Varela et al., 2001). Synchronized firing is then a time-sensitive code that links neural representations so that they can form a unified experience, such as for an object one is seeing. Treissman believes that "…attention limits might reflect limits on the number of different synchronies that can be maintained at one time, and illusory conjunctions might reflect accidental synchronies that result when too many objects are coded at once" (Gazzaniga, 2002, p. 167).

However, the synchrony that supports more complex states of consciousness must differ in several respects; most importantly, it is a large-scale coherence involving different modalities (Engel & Singer, 2001b). This type of synchrony is not equivalent to the uniform global synchrony that occurs in deep sleep and in episodes of epilepsy, which is counterproductive to consciousness (Engel & Singer, 2001b). More complex states of consciousness have been explained by postulating higher order contexts, which bind contents into progressively more complex patterns through interactions in different frequency bands. "Such higher order binding could form the basis for 'meta-representations' necessary to incorporate low-level contents into global world-and-self-models" (Engel & Singer, 2001b, p. 24).

For this present study of pure consciousness and nondual awareness, it is important to note that the coherence that might be mediating elaborate conceptual thought patterns is likely not the same kind of coherence as the one mediating pure consciousness and-or nondual awareness, because it is precisely the conceptual "world-and-self-models" that become relaxed during meditation. Thus, it is possible to have a global synchrony with a synchronous and stable alpha, theta or even delta wave frequency with eyes open, which constitutes a higher form of consciousness than that of sensory awareness or world-self concepts. As seen in preceding sections, how these two more basic levels of conscious experience become integrated with nondual awareness is known as co-emergence in the Mahamudra tradition of Tibetan Buddhism and as parinamavada in the Advaita Vedanta philosophy of Hinduism.

In hypothesizing about the nature of binding, which produces a unified sense of consciousness, Austin (2000) refers to brain wave synchrony research by Parthasarathy, who claims that mental coherence arises when peaks of gamma waves in 40 Hz frequency and theta waves in 7 Hz frequency settle into phase relationships. Zohar and Marshall (2000) see synchronous neural oscillations in the 40 Hz range as the neural basis of higher-order unitive intelligence, which they call "spiritual intelligence." In their model, synchrony is not only above the threshold of axonal firing of neurons, but also in the sub-threshold range among dentrite-to-dentrite connections that create a quantum field effect.

Possibly the most significant anatomical units for the generation of synchrony are the re-entrant thalamocortical loops (Edelman, 2004; Llinas et al., 1998). These neural circuits form either non-specific loops or specific sensory loops. Non-specific loops provide the context of experience, such as alertness, and the sensory loops provide the content (Llinas et al., 1998). A non-specific loop is the thalamic intralaminar input to layer I of the cortex and its return pathway which projects via the layer V and VI pyramidal cells to the intralaminar nuclei of the thalamus. Re-entry is along the same pathway, in addition to the connection to the reticular nucleus of the thalamus. The specific thalamocortical neurons, cortical layer IV, and the local inhibitory interneurons form the sensory loop. Re-entry of the specific loop into the thalamus is through the layer VI pyramidal cells, which can connect to the reticular nucleus of the thalamus and the corresponding specific thalamic nuclei (Llinas et al., 1998).

However, neither of these two classes of loops can generate consciousness alone. Rather, they work together to create conscious cognition. They do this by oscillating in synchrony at 40 Hz frequencies (Llinas et al., 1998). The primary role of the majority of thalamo-cortical loops is not relaying sensory stimuli. Rather, they form the feedback circuits through which neurons self-organize into globally distributed 40 Hz gamma waves. This allows for temporal binding and the functioning of conscious mind (Zohar and Marshall, 2000)

Llinas et al. conclude that "...rather than a gate into the brain, the thalamus represents a hub from which any site in the cortex can communicate with any other such site or sites" (1998, p. 1), and that therefore, "consciousness is not a byproduct of sensory inputs but rather is generated intrinsically and is modulated (or contextualized) by sensory inputs" (Zohar & Marshall, 2000, p. 76).

This complexity of thalamocortical loops indicates that the brain evolves and develops not only bottom-up, from older and more primitive structures toward the neo-cortex, but that there is also an ongoing change in the function, and even anatomy, of the lower brain centers due to their re-integration instituted by the neo-cortex. Judging by the change in the quality of awareness produced by meditative "centering," that is, by placing attention centrally within the body and brain, it is likely that the functions of the thalamus, which is so profoundly integrated with the cortex, are more complex than we realize.

Biofeedback studies using EEG, known as neuro-feedback, offer a possible model for EEG patterns of integration of pure consciousness with daily experience. Brown (2001) describes his five-phase model of treatment as: Phase I is the suppression of "bad" theta in the 3-5 Hz range and the stabilizing of beta in the 14 Hz range. Phase II works to augment beta waves – first in the low range of 15-18 Hz, and then in the high range of 20+ Hz. This augmentation is associated with focused attention and enhanced capacity for cognitive processing. Phase III is dedicated to enhancing alpha waves and achieving "the relaxation response." Phase IV is the protocol developed by Peninston (1990) where a surge in theta activity occurs simultaneously with stable and enhanced alpha waves to create alpha-theta coherence. While the cortically originating 3-5 Hz theta activity is seen as undesirable, thalamically originating theta in the range of 7 Hz is considered beneficial. Phase V constitutes a proliferation of global synchrony (EEG activity that is coherent across distant regions of the central nervous system), and this is associated with the state of creative tranquility (Brown, 2001). Brown describes the process and effects of synchrony as follows:

> Synchrony usually occurs first in the Alpha band, with progression down into upper regions of Theta and ultimately down into the lower regions of Theta, and even into what has been traditionally referred to as Delta (viz. 2 to 4 Hz). It is interesting to notice the change in the client's physiognomy and symptomatology as Synchrony is achieved and sustained, especially in the lower Theta and Delta range. The result is particularly striking for the immune system involved individuals, who report experiencing a sense of lightness and joy which has been absent for years, if they can even remember it ever being present in their lives. Ultimately, it is most transformative for Synchrony to be achieved through the lowest Theta and Delta ranges with eyes open (Brown, 2001, pp. 10-11).

This description underscores the difference in brain functioning between normal subjects, where de-synchronized patterns predominate and synchronous oscillations are only transient, and those experienced in meditation, where global synchrony is evident and stable. The presence of an ongoing alpha coherence has been reported as the most universal distinguishing feature between meditators and non-meditating subjects (Andresen, 2000). The ubiquity of the alpha wave has led some to postulate that it is the chief overall signature of consciousness (Baars, 2004). The data on synchrony also points to the possibility that meditative awareness is a result of entrainment, rather than an inherent property of mind that becomes "uncovered" in the process of meditation, as held in the Asian contemplative traditions. It is also significant that a possible equivalent of nondual awareness - synchrony in delta and theta range with eyes open – has been found to be the most transformative.

The findings of Davidson's group (Brefczynski-Lewis et al. 2005; Davidson, 2004b; Lutz et al. 2004) that the signature of meditative awareness is the appearance of large-scale fronto-parietal synchrony in the gamma spectrum, conflict with some of the TM studies mentioned previously, which found increases in the alpha-theta range. Travis' team found that long-term TM meditators report that their experience of pure consciousness co-exists with their waking and sleeping states, indicating the realization of nondual awareness. Change in the patterns of functioning of the frontal lobes, such as the forward spread of alpha waves into the frontal areas, is associated with an increased sense of the presence of a witnessing self during daily activity. The increase in frontal lobe EEG coherence suggests "greater functional co-ordination of the frontal circuits involved in the neuronal implementation of one's self-model" (Travis, Tecce, Arenander & Wallace, 2002, p. 311). An increase in coherence of 6-12 Hz frequencies in the frontal, central and parietal areas was found during eyes-open tasks. Travis primarily regards the experience of pure consciousness functioning in daily experience to be this type of alpha-theta coherence, and he finds the simultaneous presence of coherence in beta and gamma bands to indicate integration with cognitive activity.

Davidson's group, however, attributes these differences in brain wave frequencies to different styles of meditation: Meditations such as the mantra repetition meditation used in TM involve concentrated focusing of attention, which emphasizes top-down processing with the resultant slowing down of brain oscillations. In contrast, objectless meditations cultivate specific states of being, during which focusing of attention on objects is allowed to dissipate. "The dissipation of focus on a particular object is achieved by letting the very essence of the meditation that is practiced (on compassion in this case) become the sole content of the experience, without focusing on a particular object" (Lutz et al., 2004a, p.16372).

The findings of the EEG studies of pure consciousness and nondual awareness can be summarized as follows: the EEG signature of pure consciousness is the forward spread of alpha waves and the appearance of rhythmic theta trains, while the EEG signature of nondual awareness is synchrony in the gamma range occurring possible with the presence of delta waves even with eyes open. These studies indicate that nondual awareness is a state of large-scale neuronal synchrony involving both the inter-hemispheric synchrony and the fronto-parietal synchrony, and that it can function as a context for sensory, affective and cognitive processes.

The following section examines whether the neural correlates of space in the posterior parietal cortex are involved in mediating nondual awareness.

Nondual Awareness and Space

In order to provide a context for examining the possible role of the neural substrates of space in nondual awareness, this section begins with a brief theoretical background of the functions of the parietal lobes and hippocampus in the experience of space. In addition, to facilitate the discussion in this section and the later discussion of the findings and conclusions of present research, a set of fMRI data of a single subject study of nondual awareness is included in the Appendix. This scan is a part of the larger study of the neural correlates of nondual awareness that I am conducting presently at the Rutgers University, NJ. This data is used here as an illustration only, and does not constitute the main body of research.

The parietal lobes of the brain are the areas of the cortex bounded by the central sulcus, the parieto-occipital sulcus and the Sylvian fissure. The parietal lobe's anterior area consists of the postcentral gyrus (BA 1, 2, 3) and the parietal operculum (BA 43). The parietal lobe's posterior area is divided into a superior region (BA 5, 7) and an inferior region, which consists of the angular gyrus (BA 39) and the supramarginal gyrus (BA 40) (Burgess, Jeffrey & O'Keefe, 1999). According to current understanding, the "parietal lobe acts as a true sensorimotor interface contributing to the sensory guidance of movement and to perception of space by offering non-sensory, mental representations of space suited to the needs of the specific task" (Thier & Karnath, 1997, p. 11).

Of particular interest to the present study is the function of area BA 7, which includes the posterior superior parietal lobule and parts of the precuneus. This area is the terminating point of the dorsal “where” pathway (Milner & Goodale, 1995; Ungerleider & Mishkin, 1982), which is involved in processing spatial location, as well as other spatially related functions such as geometric features, egocentric framework, and visual-spatial attention and transformations (Thier & Karnath, 1997). In addition, “the loss of spatial memories after lesion of the posterior parietal cortex suggests that these memories are laid down there, with the aid of the hippocampus” (Anderson, 1999, p. 90).

The inferior parietal lobule, on the other hand, is responsible for awareness of the contralateral space, the higher order synthesis of various sense perceptions, and is involved in the ventral “what” pathway. Karnath (1999) suggests that spatial explorations and orienting in space are subserved by the neural representation of egocentric space in the inferior parietal lobule, while the visual-motor spatial processes are subserved by the neural correlates in the superior parietal lobule.

In their classic study, Ungerleider and Mishkin (1982) found two different neural pathways for processing visual input in higher order visual areas: the dorsal “where” pathway from the occipital to the superior posterior parietal cortex for processing spatial relations, and the ventral “what” pathway from the occipital cortex to the inferior temporal gyrus for processing object properties. While a number of lesion studies further confirm this basic organization (Farah, Hammond, Levine et al. 1988; Levine, Warah & Farah, 1985), there are also differing views. For example, Ramachandran (1998) [, after Goodale,] regards the dorsal pathway as the functionally "how" pathway, because of its involvement in sensorimotor control. Furthermore, Milner & Goodale (1995) believe that the ventral stream is also involved in spatial processing, albeit of a different kind. According to them, the ventral pathway mediates conscious perception of the world, and conscious perception of the allocentric spatial layout, while dorsal pathway spatial processing has more to do with navigation and egocentric coordinates of the location of objects in relation to the observer. Zacks and colleagues (1999) find the "how" pathway to be subserved by the left parietal-temporal-occipital junction area, and the "where" pathway subserved by the right posterior parietal area. Earlier studies of allocentric-egocentric spatial processing focus on the function of the medullary lamina of the thalamus and the posterior hippocampus, and they report that these structures operate like a global positioning system (Austin, 1998).

In addition to the parietal lobes, the hippocampus, a limbic structure enfolded deep within each temporal lobe, also plays a central role in the experience of space, in particular in spatial memory, such as the memory for topographic layouts of landmarks and for spatial arrays of objects. The hippocampus also facilitates the allocentric spatial frameworks (Burgess et al. 1999). Most agree that the hippocampal place cells enable these types of spatial memories (Rothenberg & Muller, 1999). Two distinct mechanisms participate in this process: "one dependent on environmental features (referred to as exteroceptive) and the other dependent on proprioceptive and vestibular cues (referred to as idiothetic)" (Burgess et al., 1999, p.183).

Evidence from existing research indicates that the brain constructs a number of different spatial representations. This contrasts with subjective experience, which informs us that we have a single spatial map of our environment in which objects and actions are represented in a unified way. Instead, the brain constructs not one space, but many spaces, continuously adjusting egocentric and allocentric spatial reference frames (Colby, 1999). Anderson (1999) summarizes this view:

> The posterior parietal cortex combines signals from many different modalities to create an abstract representation of space. The modalities involved include vision, audition, and somatosensation (neck proprioception), as well as signals derived from the vestibular apparatus and signals indicating eye position and eye velocity.…It is possible that humans' unitary impression of space, independent of sensory modality, may be embodied in this abstract and distributed representation of space in the posterior parietal cortex. (p. 101)

It is this unitary sense of space that becomes deepened and refined in the realization of nondual awareness. While the brain operates at a certain level by creating different spatial maps, from the perspective of nondual awareness, one could ask whether spatial representation becomes even more of a unitary event in nondual awareness, occurring as higher order coherence and synchrony sets in –

for not only is there sameness of space inside and outside in nondual awareness, but also in the practice of such meditation, there is a progressive decrease of the fragmentation of subjective space in general. If nondual awareness is latent and underlying all other states and functions even when not actualized, as Asian nondual philosophies claim, this implies that such unitary spatial representation exists somehow as a latent potential in the brain.

Although there is the previously reviewed research on pure consciousness that addresses the loss of the sense of space that occurs in meditative absorption (D'Aquili & Newberg, 1999, 2002; Newberg, 2000; Newberg et al. 2001; Travis et al., 2002), no one has yet researched neural correlates of space in nondual awareness. Austin (1998), however, does address the issue of the experience of space in meditation. Austin's speculation, that allocentric areas of the brain are responsible for the sense of unity during meditation—while at the same time, functioning of the egocentric areas is stopped, is relevant for my hypothesis that the neural correlates of space mediate nondual awareness. However, it is an oversimplification to see this as a choice between an egocentric and allocentric frame of reference. Nondual awareness pervades equally throughout space both inside and outside oneself. Thus, it is important not that the space as a conceptual experience need to be researched, nor the allocentric space as opposed to egocentric, but that the neural correlate of the sameness of the space inside and outside needs to be found.

Of particular interest to the present research are Austin's findings regarding space in the experience of meditation. Austin distinguishes three different levels of awareness in relation to the experience of space. This researcher quotes his table as follows:

> a) *unconscious circumspatial awareness,* the automatic sense of space normally surrounding the person, a hidden polysensory integration of space which we access in our usual daily activities; b) *ambient vision,* an automatic surge such as in internal absorption, vast unbounded space, the experience of circumspatial awareness in rare states of heightened consciousness; *c) comprehensive vision,* a brief automatic surge in kensho, space in front infused with coherent insight-wisdom, syncretism, the direct experience of all things as they really are in the absence of the personal self (Austin, 1998, p. 495).

This researcher agrees with Austin that these three levels of the experience of space in meditation exist; however, none of them represents the space of nondual awareness. First of all, the ordinary daily experience of space, which he describes as being related to the unconscious circumspatial awareness, is actually a highly edited version of the space of nondual awareness. However, it is filtered unconsciously through the "I-Me-Mine" personality structure, and also through one's entire unconscious self-world map.

Second, the ambient vision is one of the numerous unusual experiences of space that may accompany altered states of consciousness, that one commonly and floods the brain. It too is a derivative of the space of nondual awareness, only now cognized with an altered state of consciousness. Austin speculates that the stimulation of the reticular formation in the midbrain may cause the cells in the "lateral geniculate nucleus to expand the size of the visually receptive fields…" (Austin, 1998, p. 497). He postulates another possible mechanism, which involves the secondary visual system consisting of the superior colliculus, pulvinar, and posterior parietal lobe. This system is responsible for "reflexive visual responses in relation to orientations in space" (ibid, p. 497). Austin also hypothesizes that increasing the release of norepinephrine could lead to the expansion of one's internal visual field. Thus, the ambient vision, for him, is primarily an internal visual experience of space. However, the ambient vision can occur even with the eyes wide open, so that one is temporarily able to perceive objects outside of the range of one's normal visual field (Josipovic, 1998).

Third, Austin's characterization of the "comprehensive vision" occurring during insight-wisdom experience is based on the predominant activation of the frontal lobes in a surprise stimulus ("What to do about this?") and the predominant activation of the parietal lobes in a habituated stimulus ("There it is"). He postulates that during a moment of insight-wisdom that is triggered by an unexpected stimulus while the meditator is absorbed in a heightened awareness, there will be a "major fronto-parietal response" (Austin, 1998, p. 286).

With respect to the experience of space, Austin appears to hold that kensho-related space is the final level of the awareness of space. The spaciousness that is integral to nondual awareness is, however, of a different and higher order.

Using his mapping of the stages of awareness and the corresponding experiences of space, this researcher holds that the space of nondual awareness is the space of pure being, which indicates stability of realization beyond the episodes of kensho-insight. Thus, a fourth category of awareness is added to the Austin's three:

d) *nondual awareness*, an ongoing deepening realization in which the space that pervades everywhere is the sameness of space inside and outside of oneself, and one realizes oneself to be the all-encompassing being-awareness-bliss.

The scans from the data sample presented in the Appendix, support this conclusion. They show, among other results, activations in the left posterior superior parietal cortex (BA7), which is related to the experience of space from one's own perspective; in the dorso-lateral pre-frontal cortex (BA 46, 45), related to integrating the spatial dimension and mediating the bliss and compassion dimensions of nondual awareness; in the ventro-medial pre-frontal cortex (BA 9, 10) related to direct non-conceptual experiencing.

Analysis Summary

The research question this study asked was: " Do the neural correlates of space in the posterior parietal cortex mediate nondual awareness, in conjunction with the medial and dorso-lateral areas of the pre-frontal cortex?" While a number of limitations were found to exist, most significantly the scanner noise and the nature of the fMRI signal in the brain-at-rest, the answer that emerged is that neural correlates of space in the posterior parietal cortex mediate nondual awareness in large-scale fronto-parietal synchrony with the medial and dorso-lateral areas of the prefrontal cortex.

Furthermore, the space of nondual awareness is not space as a perceptual or as a conceptual experience, nor the allocentric spatial perspective as opposed to the egocentric one, but a deeper unified space of the sameness of inside and outside. It is this unitary sense of space, which is the context of all phenomenal experiencing (Sansk. Dharmadhatu), that is the space of nondual awareness.

If nondual awareness is the latent nature of consciousness, which underlies all states and functions of consciousness even when not actualized, as held in the Asian nondual philosophies examined here, this may imply that the representation of such unitary space may also exist as a latent potential in the brain. Whether implicit or explicit, such representation is necessarily located in the posterior parietal cortex.

However, nondual awareness is not limited to its spatial dimension, and thus to the functioning of the posterior parietal lobes. Its self-knowing is reflected in the simultaneous functioning of the pre-frontal cortex. In addition, nondual awareness has a luminosity dimension that is its clear light, a bliss dimension that is the basis of love and compassion; and according to the Advaita Vedanta tradition, a dimension of self-identity. Thus the neural correlates of nondual awareness are complex, involving in addition to the frontal and parietal areas, possibly: the occipital areas for luminosity, the limbic and basal forebrain areas for processing emotions, and the medial frontal and parietal areas involved in maintaining a sense of self-identity. The data sample presented in the Appendix shows activations in the posterior parietal cortex, the dorso-lateral and medial prefrontal cortex, the anterior cingulate, and the occipital cortex, consistent with this hypothesis.

In nondual awareness, the sharp difference between the stillness and emptiness of pure consciousness, on one hand, and the ceaseless unfolding of ordinary experiences, on the other, disappears and both become seamlessly integrated into oneness. This then supports the idea that nondual awareness is not the result of merely a deafferentation of certain areas in the brain, as in absorption, but of a synchrony that serves as a context and optimization of all of the brain's functions.

CHAPTER SIX: DISCUSSION

This chapter will offer an integrated theoretical model, and reflect on the meaning of the present study in the context of the relevant literature. The research conducted indicates that the neural correlates of space in the posterior parietal cortex mediate nondual awareness in synchrony with areas in the medial and dorso-lateral pre-frontal cortex. Nondual awareness is pure consciousness functioning with experience as space-like context that, phenomenologically, pervades the field of experience inside and outside of oneself.

From the analysis in the previous section, it is evident that during the experience of pure consciousness, there is an absence of perceptions, thoughts, space and time, and the sense of personal self, due to withdrawing of attention during meditation, and shutting down of the functions associated with the corresponding areas of the cortex. Thus, the best way of approaching the understanding of the neural correlates of pure consciousness is through the examination of occurrences of being awake within the deep sleep, since the absorption meditations, which lead to the pure consciousness, essentially mimic this event. When one awakes within the deep sleep a number of significant features can been noticed, such as: the complete absence of light or any other sensory stimuli; there is no sense of direction, no up or down; there is no sense of body; there is no sense of space or time; there are no images or words present; and there is no sense of one's personal autobiographic self. Yet, there is consciousness, a pure self-knowing consciousness, not different from oneself. Since the chief characteristics of the deep sleep is the predominance of cortically originating delta waves, as the cortex becomes freed from the activating influence of the brainstem's reticular formation and the thalamus, the neural correlates of pure consciousness are most likely in the cortex itself. The absence of the sense of body and the other above-mentioned features indicates that the occipital, parietal and temporal lobes are relatively inactive as well. Therefore, the pre-frontal cortex is the most likely site of the neural correlates of pure consciousness.

Furthermore, the key characteristic of pure consciousness, that it is self-knowing, leads to the question of how the brain functioning during an event of pure consciousness within the deep sleep, differs from the brain functioning during the ordinary deep sleep? The only research conducted so far on the occurrence of pure consciousness during seep sleep (Mason, Alexander, Travis et al. 1997) found an increase in the alpha-theta activity, occurring over the delta waves that characterize deep sleep. This implies that there is some, however subtle, activation of sub-cortical structures, in particular the thalamus and possibly the anterior cingulate cortex, since alpha waves are generally believed to be thalamocortically originated. The fact that the activity in the intralaminar nucleus of thalamus is necessary for consciousness to manifest is also an indication of the thalamic involvement. It is possible that activations of the basal ganglia and other subcortical regions postulated in the TM model could be due to maintaining, however unconsciously, the upright cross-legged position during TM meditation, and are not directly involved in mediating pure consciousness.

Finally, the question arises, where in the prefrontal cortex is the neural correlate of pure consciousness? Due to the constraints of the equipment, fMRI studies of pure consciousness, which can answer this question, have not been done. Newberg's research using SPECT tests indicates the activity of dorso-lateral areas of prefrontal cortex in inhibiting the posterior parietal lobes. The dorso-lateral PFC plays a major role in working memory and it is possible that, in pure consciousness, it acts to block all inputs that ordinarily converge into it, such as those from the sensory, long-term memory, limbic and other areas of the brain (LeDoux, 2006). However, research by Northoff (2003) indicates that the dorsolateral PFC is more involved in conceptual reappraisal of experience, while the medial and ventro-medial prefrontal cortex is activated in a more immediate phenomenological character of experience. Therefore, it is likely that the most significant neural correlates of pure consciousness are located in the medial areas of the prefrontal cortex.

Since nondual awareness is the pure consciousness occurring with experiences, and is space-like, the neural correlates of nondual awareness involve the areas of the pre-frontal cortex which mediate the pure consciousness, together with the areas in the posterior parietal cortex which mediate the experience of space. This idea agrees with the description of nondual awareness in the Dzogchen tradition as the intrinsic awareness that realizes the space of being (Reynolds, 1989). It extends the research of Davidson's group (Davidson et al, 2004; Lutz et al, 2004;), which identifies the fronto-parietal synchrony in gamma range as the signature of open-ended attention, accompanied with deafferentation of the orbitofrontal cortex which is involved in judgment and evaluation.

However, the axonal thalamo-cortical origination of the synchrony in gamma range has not been found. Instead, Hamerhoff (2005a) hypothesizes that the gamma range synchrony is due to dendritic gap-junction synapses within the cortex itself. In this hypothesis, the gap junction hyper-neurons formed temporarily through such connections are the neural correlates of consciousness. Hameroff (2005a) regards the gamma synchrony in 40Hz range as the electrophysiological correlate of ordinary human consciousness, and the synchrony in the higher frequencies of 80-120 Hz found in some long-time Tibetan Buddhist practitioners, as representing the highest development of human consciousness. Crick & Koch (2005), point to the claustrum as the missing link in the neural correlate of consciousness, due to its hypothesized role in connecting all areas of the cortex, and especially in coordinating the fronto-parietal cortico-cortical connections. These direct connections between the frontal and the parietal cortex may be involved in the gamma range synchronies found during nondual awareness meditation.

Lateralization and asymmetry in the prefrontal cortex found by Davidson's team, (as well as by this researcher, as shown in the Appendix)—significant increase in the activity of the left dorsolateral pre-frontal cortex—brings into question previous conclusion that the neural correlates of pure consciousness are in the medial areas of prefrontal cortex. However, this difference is due to the similarity of pure consciousness to the deep sleep, in contrast to nondual awareness, which functions as the context of daily experiences. Nondual awareness is characterized by being fully awake and present to the spontaneous unfolding of one's experiences. Thus, the dorso-lateral prefrontal cortex does not exercise the blocking activity, as it does during pure consciousness. Rather, it functions in its natural role as a part of the executive attention network (Fan, McCandliss, Fossella et al., 2005).

The differential increase of activity in the left dorso-lateral prefrontal cortex during meditation has been associated with the increase in the feelings of happiness and joy (Aftanas & Golosheykin, 2001; Davidson, 2004). This increase can also be interpreted from the viewpoint of traditional meditation theory: the 'left' energy channel sustains the experience of bliss dimension of nondual awareness, which in the ordinary dualistic mode of cognizing becomes the experience of craving and desire; while the 'right' channel sustains the experience of clarity or luminosity dimension of nondual awareness, which in the ordinary dualistic mode of cognizing becomes the experience of anger and frustration (Guenther, 1977). This could explain the increase of activation in the right dorsolateral prefrontal area during stressful situations, as anger builds up and clarity is needed. The medial and ventro-medial prefrontal cortex, which in this analogy corresponds to the central channel that sustains the experience of emptiness, would then be more involved in mediating pure consciousness and the open-ended empty aspect of nondual awareness.

Recent findings indicate that the human brain is intrinsically organized into two functionally anti-correlated neural networks: the extrinsic network consisting primarily of the dorso-lateral prefrontal cortex, the anterior cingulate gyrus and the lateral parietal cortex, and the intrinsic network consisting primarily of the medial pre-frontal cortex, the medial parietal cortex, the posterior cingulate gyrus, and the pre-cuneus (Fox et al, 2005; Raichle et al., 2001; Raichle & Gusnard, 2005). The extrinsic network is related to attention and working memory, while the intrinsic network appears to support self-referential processes (Northoff, Heinzel, de Greck et al., 2006). Furthermore, the extrinsic network is activated in the attention-demanding tasks focused on object/activity external to oneself. In contrast, the intrinsic network is activated during internally focused tasks, especially those that are relevant to one's self. This difference reflects the natural division of space into external and internal space.

The fMRI data from the single subject study of nondual awareness presented in the Appendix show activations in the areas encompassing both networks. This can be attributed to the balancing of attention and awareness between external and internal experiences. The sameness of internal and external space that characterizes nondual awareness is reflected in the simultaneous harmonious functioning of the ordinarily anti-correlated intrinsic and extrinsic neural networks. The ability of large-scale fronto-parietal synchrony found in nondual awareness to constrain cognitive and affective processes mediated by diverse cortical and subcortical structures, further indicates that the two networks are operating simultaneously.

This larger integrated network may then be the long-sought neural correlate of the unified nature of consciousness. If nondual awareness is one's 'original mind' that underlies all states and functions of consciousness even when not actualized, as held in the Asian nondual philosophies examined here, this may imply that this larger integrated neural network is the innate natural state of the brain, present as a latent potential underneath the dichotomy of ordinarily anti-correlated networks.

Since the chief characteristic of nondual awareness is the sameness of internal and external space, it is also likely that the areas in the posterior parietal cortex that mediate the experience of space, are functioning as a part of neuronal switch that operates at the onset of meditation and allows the shift from dualistic to nondual awareness.

The above then presents a model of the functioning of the brain in nondual awareness. The remainder of this chapter will reflect on the meaning of the present study in the context of the relevant literature.

Pure Consciousness and Nondual Awareness

The finding that nondual awareness is the pure consciousness functioning with experiences as space-like context, agrees with the majority of sources in the Hindu tradition of Advaita Vedanta, and in the Tibetan Buddhist traditions of Dzogchen and Mahamudra. It disagrees with the position of a number of Mahayana and Teravada schools of Buddhism, which see consciousness only as momentary dualistic subject-object cognition. Furthermore, these findings are relevant to the general direction of the meditation research, which this researcher believes should be focused on the pure consciousness and nondual awareness. As stated in introduction, the neural correlates of consciousness cannot be found solely through researching the functions and states of consciousness. This conclusion is in agreement with Taylor (2003) and Deikman (1996). It contradicts the functionalist approach as represented by Churchland and Sejnowski (1993). However, it differs from both Taylor and Deikman, in that the emphasis in meditation research ought to be placed on nondual awareness rather then on the pure consciousness. Discovering how nondual awareness manifests in daily experiences could potentially lead to significant new understandings of the neural correlates of consciousness, since it implies that the nature of consciousness is present together with various states and functions of consciousness.

Several conclusions pertaining to the general understanding of the nature and the structure of consciousness in the Asian nondual philosophies can be recapitulated in order to further contextualize present findings.

According to Asian nondual philosophies, consciousness has the following structure: Nature>Substrate>States>Functions>Contents.

This indicates that the nature of consciousness (pure consciousness) encompasses all of its structures; the unconscious substrate encompasses the states of consciousness; the states of consciousness encompass the functions, and the functions encompass the contents. As seen in the previous research of the sources in Dzogchen, Mahamudra and Advaita Vedanta traditions, the nature of consciousness is to be conscious. It can be described as empty, self-knowing cognizance without any content. Consciousness-as-such has been termed the pure consciousness in Advaita Vedanta; 'pure' indicating that is without any experiences and without change. In Tibetan Buddhism it is termed the 'clear light'. That pure consciousness can recognize itself or, encounter itself directly, without reliance on thoughts or imagination, as discovered in these traditions, indicates that pure consciousness is non-propositional in nature. In concluding this, the present study disagrees with those views in Western philosophy and cognitive psychology which see consciousness as being a construct and propositional in nature (Katz, 1978; Phylyshyn, 2002).

The above findings regarding the pure consciousness provide the context for discussing the more specific findings about nondual awareness in light of existing literature.

Nonduality is the central tenet of Asian philosophies. It is both the foundation and the goal of meditational philosophy-cum-praxis. Loy (1998) describes nonduality as characterized by the four features: centrally, it is an absence of subject-object dichotomy that manifests in threefold way, as nondual or pure perception, nondual or intuitive thinking, and as nondual or spontaneous acting. To this the present study adds the fourth, nondual emotion often labeled as compassion or unconditional love. Nondual awareness, from this perspective, is that aspect of consciousness that experiences or more precisely, realizes nonduality. As such, it is distinguished from the ordinary conceptual mind which cognizes dualistically, through the use of subject-object concepts. Nondual awareness can be equated with the Hindu term *prajnana*, the Indian Buddhist *prajna*, or Tibetan term *rigpa*.

The finding that nondual awareness is pure consciousness functioning with experience as space-like context agrees with teachings on rigpa and co-emergence within the Dzogchen and Mahamudra traditions, respectively. It also agrees with certain interpretations of the parinamavada doctrine within the Advaita Vedanta. These conclusions are in agreement with the views of a number of Tibetan Buddhist philosophers such as Longchepa (Rabjam, 2001a), proponents of Vedanta such as Radhakrishnan (1995), and the Transpersonal psychologists such as Almaas (1996), Blackstone (1997, 2005) and Wilber (1987, 2000a, 2000b). The above conclusions contradict those views and theories which do not recognize the possibility of nondual awareness or the pure consciousness functioning with experiences, such as the vivartavada doctrine of Advaita Vedanta (Shepetin, 2004).

The relationship of nondual awareness and experience is sometimes termed the union of absolute and relative. It is described as the simultaneous transcendence and immanence (Radhakrishnan, 1995), or alternatively, as co-emergence (Namgyal, 2001). This means that, while nondual awareness is independent from experiences and not conditioned by them, it is at the same time an inseparable from experience, so that, phenomenologically, all experiences have the same quality of emptiness-luminosity-bliss, as does the nondual awareness itself. Thus, as metaphors state, nondual awareness and experiences are like the sun and its rays of light, or like the water and its wetness. This view is in accord with the texts of Mahamudra tradition which term this oneness of awareness and experience “one taste”, in which nirvana or nonduality and samsara or duality, are the same (Rangdrol, 1989).

It also agrees with Radhakrishnan’s way of seeing this relationship of nondual awareness and experience as simultaneous transcendence and immanence (Radhakrishnan, 1995). However, the present study does not make theological inferences based on it.

This researcher proposes five stages of the realization of the union of absolute and relative, of nondual awareness and phenomenal experiencing. These can be considered as a re-formulation of the teachings on the five ranks of Zen master Tozan (Yu, 1971) in light of the Dzogchen, Mahamudra and Advaita Vedanta, as follows:

a) Absolute only: pure consciousness alone; transcendence described in vivartavada doctrine, or the clear light in anuttara tantra;

b) Relative within Absolute: experiences occur in the context of nondual awareness, like objects within space or images within a mirror;

c) Absolute within Relative: immanence described in parinamavada doctrine; all experiences appear as if made of nondual awareness itself, like pots made of clay or jewelry made of gold;

d) Co-emergence or Mahamudra: simultaneous transcendence and immanence, self-knowing nondual awareness and experiences arising inseparably together, so that the nondual awareness simultaneously knows both its nature and the nature of experiences;

e) Union or nonduality: complete oneness; one taste as inseparable being-awareness-bliss or emptiness-luminosity-bliss, Advaita Vedanta also claims that this oneness is the Self.

A statement is sometimes made by those who recognize the possibility of pure consciousness functioning with experience as nondual awareness, that since nondual awareness is experienced as space-like or identical to space, therefore nondual awareness pervades everywhere like space literally (Venkatesananda, 1984). Alternatively, since in the realization of oneness everything appears as not different from nondual awareness, therefore everything is actually made of nondual awareness or consciousness. Here, the question is whether extending the phenomenological truth to a metaphysical level constitutes a valid inference. Contrary to the general thrust of the arguments in Asian philosophies, there is no way to ascertain, either based on the experience or based on logic, whether this kind of a metaphysical idea is accurate or not. While in meditation, nondual awareness may appear to extend throughout the space and to be identical with it, whether this is true on some deeper level, beyond even the quantum energy states indicated by Bohm (1984), cannot be ascertained based on one's experience.

Thus, it is better to describe the process of realizing oneness as: the nondual awareness realizing the space of phenomena or the space of being (Sansk. Dharmadhatu), even though in terms of the subjective experience, as Longchepa points out (Rabjam 2001a), nondual awareness is identical with space.

Neural Correlates of Pure Consciousness and Nondual Awareness

This section will contextualize the findings of the present study within the relevant literature on the neural correlates of consciousness.

Chalmers (2000) distinguishes several different levels of neural correlates (NC) of consciousness: NC of the overall state of being conscious; NC of the various states of consciousness; and NC of the contents of consciousness. To this, the present study adds the neural correlates of pure consciousness or the nature of consciousness, and the neural correlates of nondual awareness, with a caveat that to understand these neural correlates the difference between the nature of consciousness on one hand, and the states, functions and contents of consciousness on the other, as outlined in the preceding pages, has to be kept in mind.

The overall state of being awake and conscious is critically dependent on the activity of the three sub-cortical structures: reticular formation of the brain stem, intralaminar nuclei of thalamus and the basal neuromodulatory nuclei (Baars, 2005a). The three natural daily states of consciousness of waking, dreaming and deep sleep (which includes all four stages of non REM sleep), are subserved by the activity of the reticular formation of brainstem, which secretes neurotransmitters controlling the overall state of the brain's wakefulness, as well as by the inhibitory activity of the basal forebrain (Guyton, 1987). The excitatory and the inhibitory activities of these two structures influence the intralaminar and reticular nuclei of thalamus and through them the cortex (Arenender, 1996). Thus, the neural correlates of the three natural states of consciousness, waking, dreaming and deep-sleep, are found in the sub-cortical regions of the brain.

In contrast to this, the functions of consciousness are dependent on the activity of the cortex (Baars, 2005a). In addition to the sensory and motor functions, the neural correlates of all cognitive functions such as language, imagery, abstract thought, attention, memory, etc. are located in the cortex (Cabeza & Kingston, 2001). Baars (1997) describes the work of Gazzaniga who studied split-brain patients and found that the narrative self that receives and comments on the conscious sensory input is situated in the left prefrontal cortex, while its nonverbal counterpart is in the right prefrontal cortex. These and other numerous similar findings have led to the generally held view that the neural correlates of consciousness reside in the cortex, and in particular in the pre-frontal area (Crick & Koch, 1998; Koch, 2004). "The activity of all subcortical and extratelencephalic centers of the brain, regardless of how important they are for the appearance of consciousness, is never accompanied by consciousness. …The prefrontal cortex …[is] the highest brain center and the seat of the soul, of consciousness, personality, intelligence, and so on" (Roth, 2002, pp.79-83).

Koch (2004) postulates an intermediate level theory of consciousness according to which one is not aware either of the external world nor of the internal thoughts and feelings, but only of their neural representations and re-representations solicited from the sensory and language areas of the brain by an unconscious homunculus located in the pre-frontal cortex (2004). This researcher agrees with his focusing of attention on the importance of the pre-frontal cortex, as well as with Searle (2005) who criticizes his theory for its extreme interpretation of the neural representations, and for the limited scope of awareness it postulates. As Searle points out, awareness of sensory representations does not preclude the existence of the external reality, nor is one aware of the sensory content only.

In addition to the view that sees the seat of consciousness as being in the cortex alone, the thalamocortical loops have been thought for some time to be the neuronal seat of consciousness. As Edelman (2004) states, the thalamocortical system, which he calls the dynamic core, speaks mainly to itself, and it is this property that distinguishes it from those structures that do not subserve consciousness.

> Higher order consciousness, which allows its possessor to be conscious of being conscious, to have a socially defined nameable self, and to have a concept of the past and the future, arises by evolution of an additional reentrant capability. This occurs when concept-forming areas involved in primary consciousness are linked by reentrant circuits to areas mediating semantic capability. …This view sees the development of reentrant pathways and circuits between the frontal and the temporal lobes as the most significant for the evolution of the higher-order consciousness.

> Furthermore, the connection between the concepts of self and time, on one hand, and the primary consciousness on the other, is believed to be instrumental in making the consciousness of consciousness possible (Edelman, 2004, p.105).

The above theory describes the mechanisms of our everyday conceptual consciousness. However, from the viewpoint of the pure consciousness it could be said that in addition to both the instinct as the way of knowing available to the primary consciousness, and the conceptual reason (that operates in words, images and numbers) available to higher-order consciousness, there is also the intuition which is the mode of knowing available to the pure consciousness and nondual awareness. In other words, to be conscious of being conscious, as a word-thought, as in thinking about one's consciousness, is very different from directly realizing the nature of consciousness, from consciousness encountering itself directly and non-conceptually. This means that the areas of the brain involved in subserving the primary consciousness or the rational-semantic consciousness may not necessarily be involved in subserving the pure consciousness. Zaidel's research confirms this consclusion: "Recognizing that the disconnected Right hemisphere is conscious provides additional evidence that language is not necessary for human consciousness" (Zaidel, 1994). Thus, consciousness knowing itself is simply the property of consciousness itself, and not the result of a particular function or content of consciousness.

Neural Correlates of Space in Nondual Awareness

The contribution of the present study to the field of meditation research and cognitive neuroscience in general, is the finding that the neural correlates of the experience of space in the posterior parietal cortex mediate nondual awareness in synchrony with medial and dorso-lateral areas of the pre-frontal cortex. This large-scale synchrony, which constrains cognitive and affective processes, indicates the activation of a larger neural network, one that integrates the ordinarily anti-correlated intrinsic and extrinsic networks.

A significant issue that needs to be addressed regarding the function of the neural correlates of space in nondual awareness concerns the difference between the extraordinary coherence and unity of the experience of space in nondual awareness, and the multiplicity of spaces that constitute one's mental experience of space. For example, four different types of mental spaces are postulated: the space of the body, the space around the body, the space of navigation, and the space of cognitive tasks (Tversky, 2001, 2002; Morrison & Tverski, 2004). These mental spaces are contrasted with the unified physical space. The question arises then: how is the space of nondual awareness related to these types of mental space? Or more precisely, is the space of nondual awareness a conceptually generated image of space? Kosslyn, Ganis & Thompson (2001) define mental image as the experience of perception without an external stimuli, created by accessing the perceptual information from memory. They point to the activations in the primary and, especially, in the secondary visual areas in the occipital cortex as the chief feature of mental imagery. Imagining space would also activate the dorsal stream in the superior parietal areas. In addition, the middle temporal gyrus, the inferior temporal gyrus and the fusiform gyrus may be activated as well, as they are the locus of visual memories (Kosslyn & Thompson, 2003). Sample data presented in the Appendix show no activations in these areas indicating that the subject is not accessing an image of space from the memory. Thus, while it is likely that some of the areas of the brain involved in mediating nondual awareness are same as those mediating an image of space, the distinguishing feature would be the large-scale fronto-parietal synchrony, which is absent in ordinary experience, as well as, the absence of activations in the temporal cortex.

The activation of the posterior parietal areas (BA 7) mediating the experience of space in nondual awareness can be related to the theatre metaphor of Global Workspace Theory (Baars, 1997). In this metaphor, conscious content is limited to the spotlight of attention on the stage. The contents of working memory competing for attention, behind the scene context operators, and the audience of various cognitive systems, are in the dark, pre-conscious or unconscious. Nondual awareness can be compared to turning on the lights in the theatre, or at least backstage, while the show is still going on. This would correspond to activation of the posterior parietal areas involved in spatial processing, in large-scale synchrony with pre-frontal cortex. The result is a characteristic loss of foreground/background contrast, which has been reported by the meditators experienced in the practice of nondual awareness meditation (such as the subjects participating in the fMRI study of nondual awareness currently conducted by this researcher at the Mental Imagery and Human-Computer Interaction laboratory, Rutgers University, Newark, NJ).

CHAPTER SEVEN: SUMMARY, CONCLUSION AND SUGGESTIONS FOR FUTURE RESEARCH

Through theoretical research of the literature, the present study examined the hypothesis that the neural correlates of space in the posterior parietal cortex mediate nondual awareness in synchrony with the medial and dorso-lateral areas of the pre-frontal cortex. It explored current findings and the limitations of research on the neuroscience of nondual awareness, and offered a theoretical model that points to a large neural network, which integrates the ordinarily anti-correlates extrinsic and intrinsic networks, as being the long-sought neural correlate of unified consciousness.

It explored the idea of nondual awareness as held in the Asian nondual philosophies of Advaita Vedanta, Dzogchen and Mahamudra, and the contemporary meditation research in Cognitive Neuroscience. It outlined what pure consciousness is according to these Asian traditions, and examined whether nondual awareness is pure consciousness occurring with experience. It then, looked for the evidence of the neural correlates of pure consciousness in the EEG research of meditation, and analyzed the function of the neural correlates of space in meditation, from the evidence collected by the advanced neuroimaging studies such as fMRI and SPECT. In this way, the present study addressed the general lack of the recent studies of meditation, and in particular, the complete lack of the studies of nondual awareness.

The conclusion of the present study is: nondual awareness, which is pure consciousness occurring with experience, as a space-like context, is mediated by the neural correlates of space in the posterior parietal cortex, in large-scale synchrony with the areas in the medial and dorso-lateral pre-frontal cortex. This large-scale synchrony, which constrains cognitive and affective processes, indicates the activation of a larger neural network, one that integrates the ordinarily anti-correlated intrinsic and extrinsic networks. The present study suggests that this larger integrated network may be the long-sought neural correlate of the unified nature of consciousness, and may be the innate natural state of the brain, present as a latent potential underneath the dichotomy of the ordinarily anti-correlated networks.

* * *

The human brain is the most complex, highly organized matter we know of in the universe, and nondual awareness or unity consciousness is, arguably, the most advanced and mysterious state of consciousness that the human culture has ever recorded. Allowing the viewpoints of the Cognitive Neuroscience and the Asian nondual philosophies to co-exist, it can be said that the two, the brain and nondual awareness, represent the two sides of the great mystery of Being in search to know itself.

I hope that the present study makes a contribution toward this understanding.

Because meditation ultimately deals with the nature of consciousness itself, which underlies all cognitive processes, the topics of future meditation research are numerous.

To begin with, nondual awareness is regarded in the Advaita Vedanta, Dzogchen and Mahamudra traditions as an innate potential common to all humans. Future research could explore whether the large-scale fronto-parietal synchrony that is the neuronal signature of nondual awareness, already pre-exists in some form as a potential in the brain, and to what extent it integrates the ordinarily anti-correlated networks. It can then be explored whether this larger integrated network is indeed the neural correlate of unified consciousness.

In relation to nondual awareness, an important area of future research is the central channel (Sansk. sushumna nadi). Asian contemplative traditions hold that a variety of different levels and qualities of consciousness can be accessed in dependence on the placement of attention in relation to the central channel. This can mean both the vertical change of focus from chakra to chakra which results in a change of quality, such as love, will, passion, wisdom etc., and the horizontal change in relation to the center of the channel which produces the experience of different levels of subtlety, form the gross perceptual level to the most subtle level of pure consciousness.

Another area of particular interest for the research of nondual awareness are the occipital lobes. Ordinarily, the occipital lobes are not thought to be involved in generating awareness. However, in addition to processing visual stimuli, they also function in activating the frontal, parietal and temporal lobes.

This can be related to the traditional descriptions of consciousness that compare consciousness with light, and the lack of consciousness with the darkness, and also the light with the enlightenment or the awakening of consciousness to itself. These statements might indicate involvement of the pineal gland as well, due to its effect on regulating the light-dark cycle. Future research of the occipital lobes and the pineal gland functions in nondual awareness may lead to an evolutionary hypothesis of consciousness, according to which the experiences of space and light are the most basic elements necessary for the emergence of self-aware consciousness, since they are phenomenologically its two main characteristics.

The present research on the neural correlates of space in nondual awareness makes a contribution toward the goal of finding the neural correlate of consciousness. This, in turn, would advance the possibility of finding whether the continuum of consciousness is independent of the physical body, as many contemplative traditions assert. Resolving this issue would constitute a major social and cultural breakthrough.

APPENDIX: DATA SAMPLE

The following are preliminary fMRI data obtained from a single subject during nondual awareness meditation. This scan is a part of the larger study of the neural correlates of nondual awareness presently conducted by this researcher at the Visual/Spatial Cognition and Computer-Human Interaction laboratory at the Rutgers University, Newark, NJ. The data is used here as an illustration only, and does not constitute the main body of research in this dissertation.

Experimental Procedure

Subject, the author of this dissertation, was a forty-six year old male, right handed, with twenty-five years of meditation experience, mostly in the Tibetan Buddhist tradition. He was familiar with MRI procedures. The scan was performed in the late afternoon. The subject had his usual cup of coffee in the morning and no other stimulants or depressants in the intervening time. Previous research indicates that the length of meditation practice differentially affects cerebral blood flow and cortical activation, resulting in the larger increase of BOLD signal among the long-term meditators compared to novices (Brefczinski-Lewis et al. 2005).

Stimulation protocol was a block design: 20 second rest, 3 minute meditation, 20 s rest, 3 min counting (adding simple numbers). This was repeated two times, and this series was run once. The duration of the protocol was limited by the time constraints. More repetitions would have increased the power of analysis. The 20 second rest periods were used in order to allow the hemodynamic response to return to normal, and are considered sufficient time for this to occur (Goebel & Jansma, 2004). Counting consisted of adding single digit numbers while focusing on the point between eyebrows, to underscore the difference between the evenly spread attention of nondual awareness, and the focused attention of conceptual mental activity. In the Asian contemplative traditions, meditation is believed to permanently alter the mental functioning of long-term meditators. fMRI evidence for these claims is beginning to emerge (Davidson, 2004b). It is thus possible that both long-term and short-term effects of meditation extended into counting condition. However, the change in the manner of deploying attention was intended to control for this. The entire procedure was performed in a dimly lit scanner room, to reduce possible distraction due to visual stimuli. Another run not represented in the images shown here, repeated the same procedure but with eyes open and while looking at an image of a mandala.

Scans were acquired using the Siemens-Fujitsu 3 Tesla Allegra scanner with full head RF coil. Changes in BOLD signal were measured using a gradient-echo echoplanar sequence (TR = 2000, TE = 30, 32 axial slices, 4mm thickness, 0 gap, matrix resolution 64x64, 411 measurement total). During the same run, both T2 saggittal and T1 axial anatomical scans were obtained, which were used to overlay the functional data.

Data Analysis was performed with Brain Voyager QX software. Stimulation protocol was created alternating the three conditions in the above-mentioned order. Data preprocessing involved 3-D motion correction, slice scan time correction and temporal data smoothing. Spatial smoothing was not performed in order avoid blurring (Goebel & Jansma, 2004). General Linear Model (GLM) was used to analyze the whole brain data. (Region of interest, ROI, analysis will be performed at a later date.) GLM is a standard method of analysis for fMRI software today. For analyzing the functional brain images, it is a considerably more powerful analysis method then a simple correlation or t-test, as it can specify many explanatory variables or predictors. In order to remove the noise and increase accuracy of detection, the threshold clustering was set at 8 voxels, and the p value low at 0.000003.

> Using the General Linear Model, the statistical model specified in a design matrix is compared with a measured time course at each voxel. The comparison of the model and the data is expressed as an R or F value for each voxel, which tells how good the overall model fits or explains the data. If the R or F value of a voxel passes a statistical threshold, the respective voxel will be highlighted by appropriate color coding (Goebel & Jansma, 2004, p. 19)

The images that follow represent statistically significant activations in yellow or red square dots. Images #1 to #7 show the areas where activation was higher during nondual awareness meditation compared to the rest. Image #8 shows the area where the activation was higher during meditation then during the counting (meditation compared to rest minus counting compared to rest). Graphs showing the time course, and the fMRI response (as changes in the percentage of

BOLD signal, with error bars, and the time in slices on the horizontal axis), are provided for the most relevant areas of activation.

Results and Discussion:

Image 1 represents 32 axial slices through the brain, top to bottom, in radiological fashion with left and right sides reversed, showing activations during nondual awareness as compared to the rest condition. The following selection of slides describes the activations in more detail.

Image 2 (slide 7) shows activations during nondual awareness meditation compared to the rest condition, in the somatosensory cortex (BA 1,2 & 3), which is associated with the overall awareness of sensations/energy during meditation, as well as in the right posterior superior parietal area (BA 7), which is associated with the space-like quality of nondual awareness.

Image #2a shows the graphs for the time course and the fMRI response for the posterior parietal area BA7. As mentioned previously, both meditation and counting engage the parietal cortex in the overlapping areas. The activation in this area during nondual awareness is higher then during the rest, but lesser then during counting.

Image #3 (slide 9) shows the activations in the inferior parietal cortex that have been associated with spatial explorations and orienting in space, (Karnath, 1999). These activations may indicate the spatial dimension of nondual awareness. As with the posterior parietal cortex, the activations during counting were higher then during meditation, due to the function of this area in processing mathematical operations (Hubbard, Piazza, Pinel et al. 2005).

Image 4 (slide 15) depicts activations in the left dorso-lateral prefrontal cortex (BA 45, 46, 9), which has been found to be significantly involved in subserving the bliss and compassion dimensions of nondual awareness (Davidson et al. 2004); as well as participating in the fronto-parietal EEG synchrony characteristic of certain types of meditation (Lutz et al. 2004).

Image #5 (slide 19) again depicts activation in dorso-lateral prefrontal cortex, (areas BA 46, 45,), together with the activations in occipito-parietal junction (areas 39 and 37) which participate in integrating experience into coherent whole—the 'wholeness' of experience is one of the hallmarks of nondual awareness. Activations within the occipital cortex (BA 17, 18) indicate the involvement of visual areas even in the absence of visual stimuli. This may correlate with the perceived luminosity of nondual awareness and with the traditional descriptions of consciousness that compare consciousness with light, and the lack of consciousness with the darkness.

Image #6 (slide 21) shows significant new activations in the medial pre-frontal and the anterior cingulate cortex (BA 32, 24). This area of the brain has been associated with the ability to hold attention during meditation (Lazar, 2000), and is a part of the intrinsic network (Raichle et al., 2001). Graphs show higher activation in this area during meditation then during counting, even though the counting was a more narrowly focused activity. This may also be due to the fact that this area mediates a sense of self, thus possibly indicating that the self is an integral dimension of nondual awareness and of consciousness in general (Feinberg and Keenan, 2005).

Image #7 (slide 23) shows again the activation in the anterior cingulate gyrus and the visual cortex. New activations are in the medial and ventro-medial prefrontal cortex (BA 10, 11), the areas that have been associated with direct non-conceptual experiencing (Northhoff, 2003), which is the mode of experiencing of nondual awareness.

Image #8 (slide 25) shows the areas in the brain where the activation was higher during meditation then during the counting (meditation compared to rest minus counting compared to rest). Since counting is a conceptual activity involving focusing, higher activations were found during counting then during meditation in those areas that are required for mathematical processing, in the pre-frontal and parietal cortex (Hubbard et al. 2005). The only area with statistically significant higher activation during nondual awareness meditation then during counting in this subtraction was is the right inferior occipito-temporal cortex (BA 37), which is associated with integration of sensory stimuli. Interestingly, it is also one of the only two areas (the other being anterior insula), where the increase of cortical thickness due to meditation correlates with the length of meditation practice (Lazar, 2005).

Image # 1

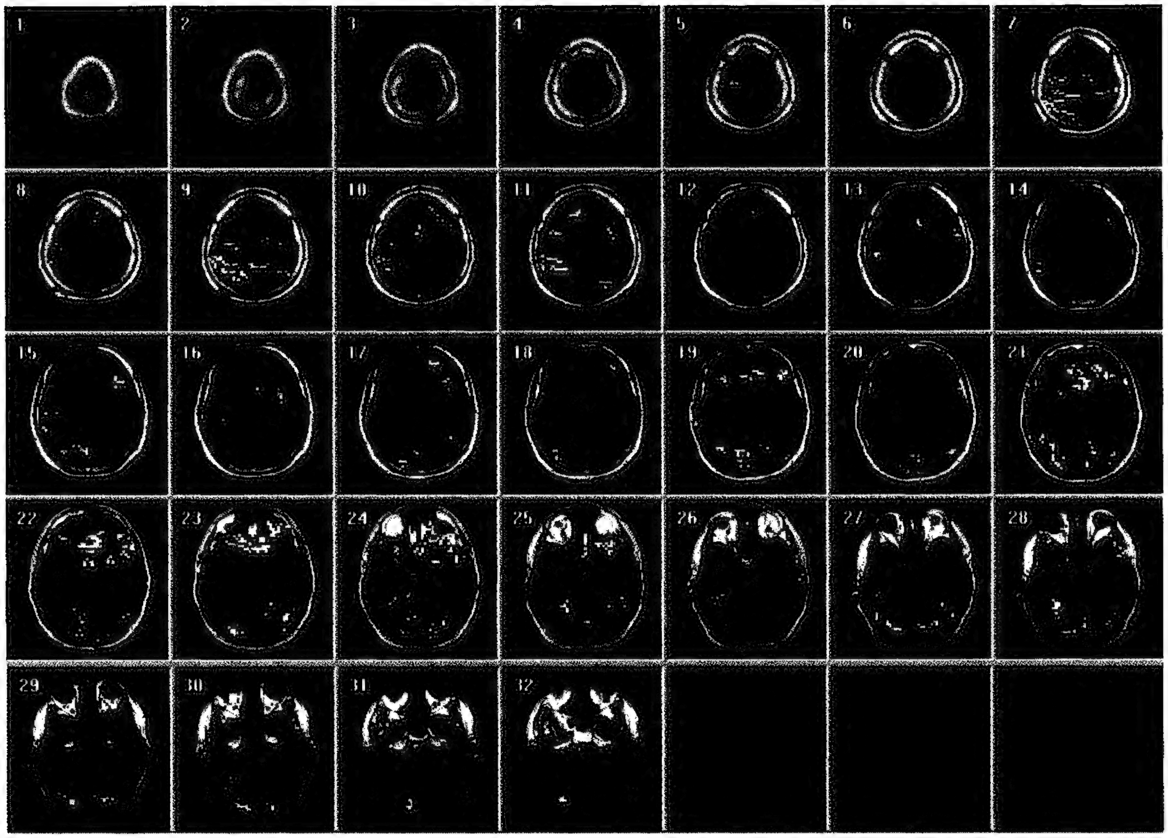
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Image #2

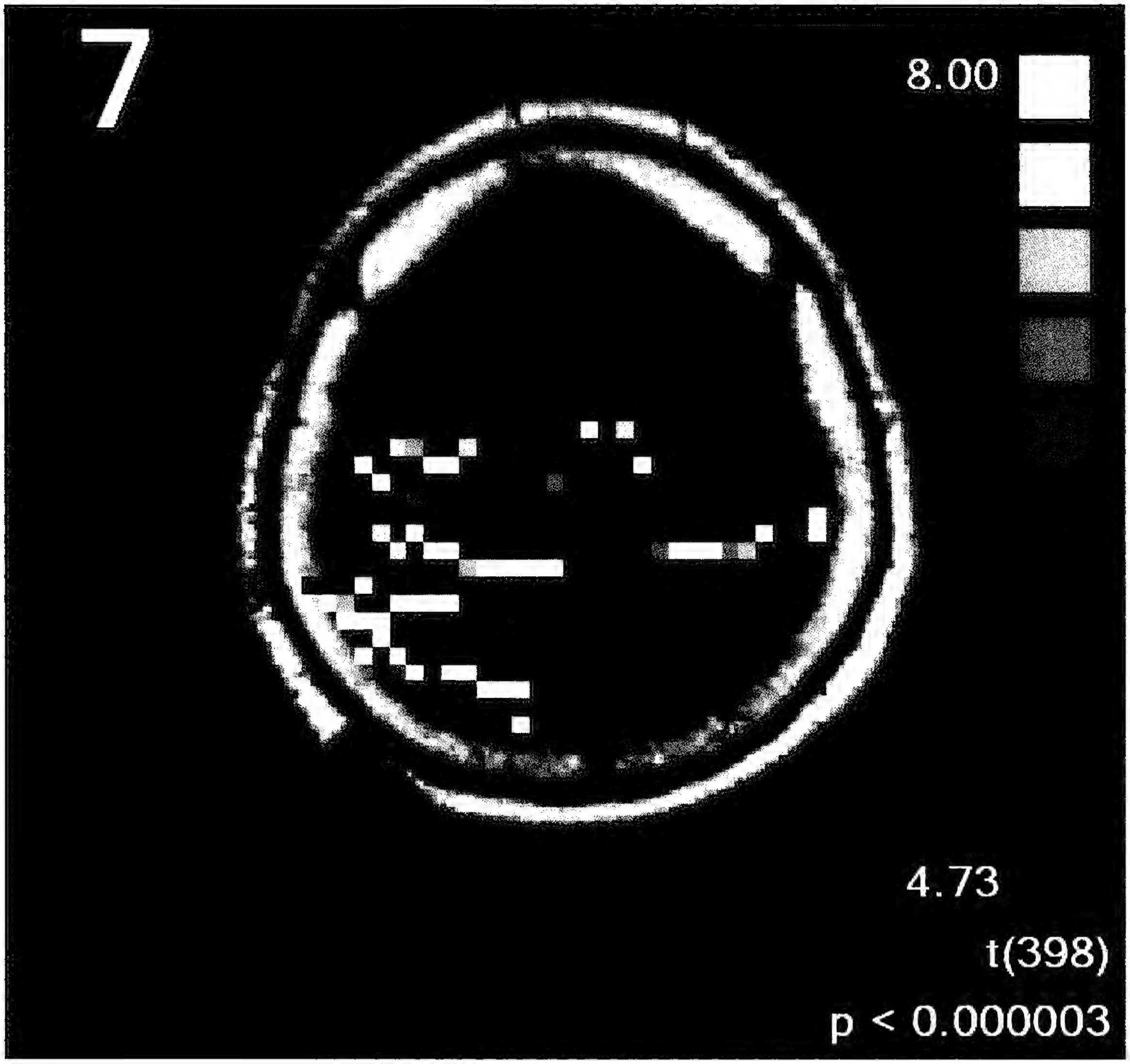
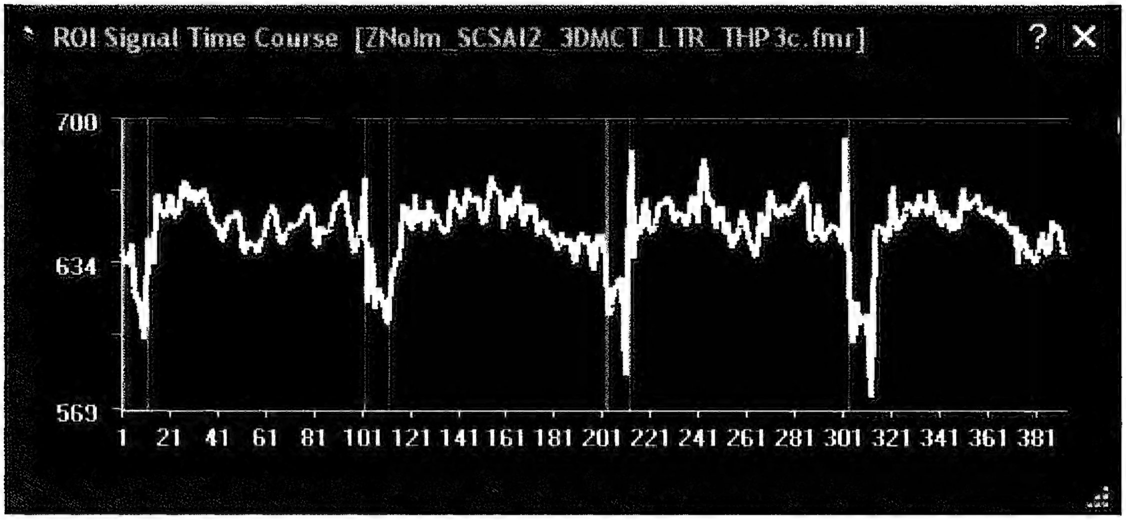


Image #2a

Signal Time Course and FMRI response for the right posterior superior parietal cortex (BA 7): green-rest; blue-meditation; gray-counting.



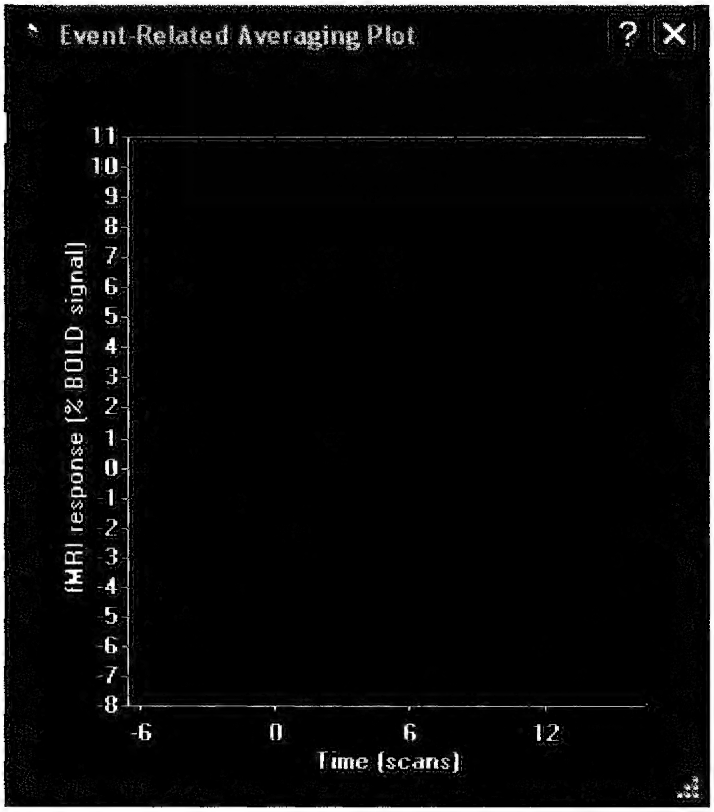


Image #3

Inferior parietal cortex (BA 40)

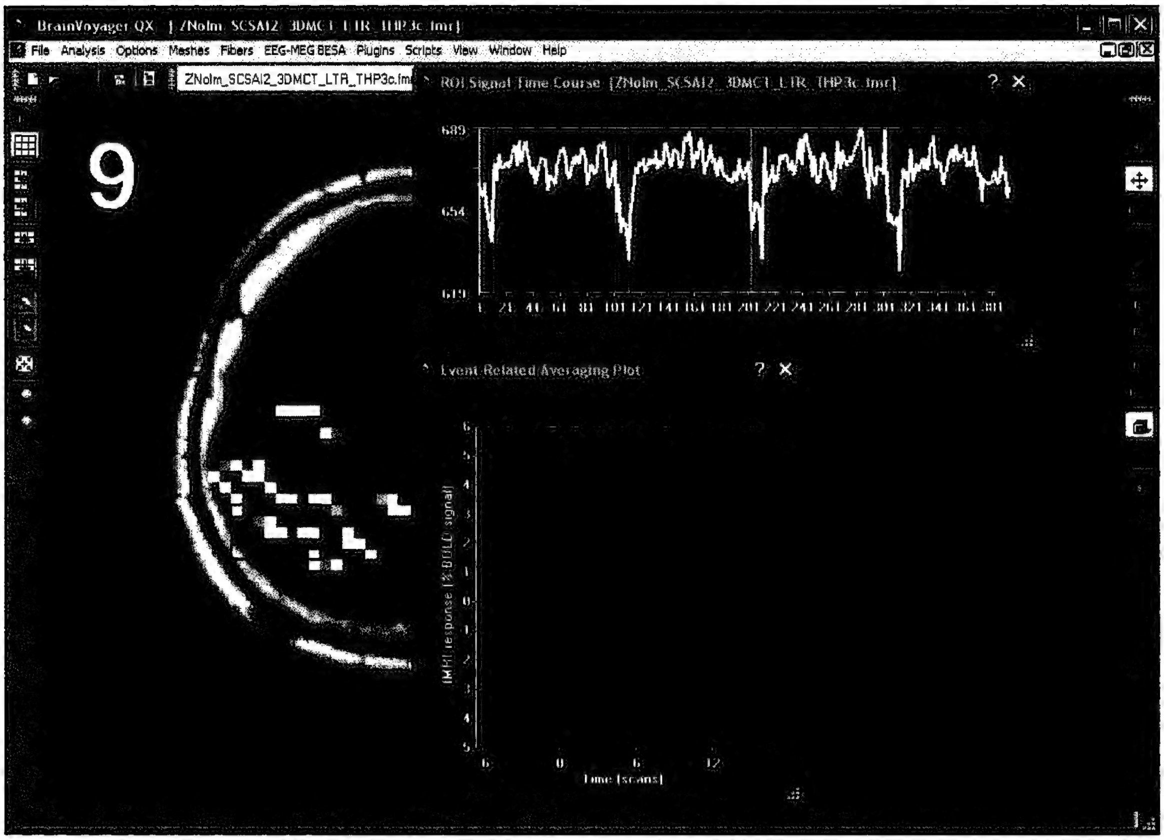


Image #4

Left dorso-lateral pre-frontal cortex (BA 9, 45, 46)

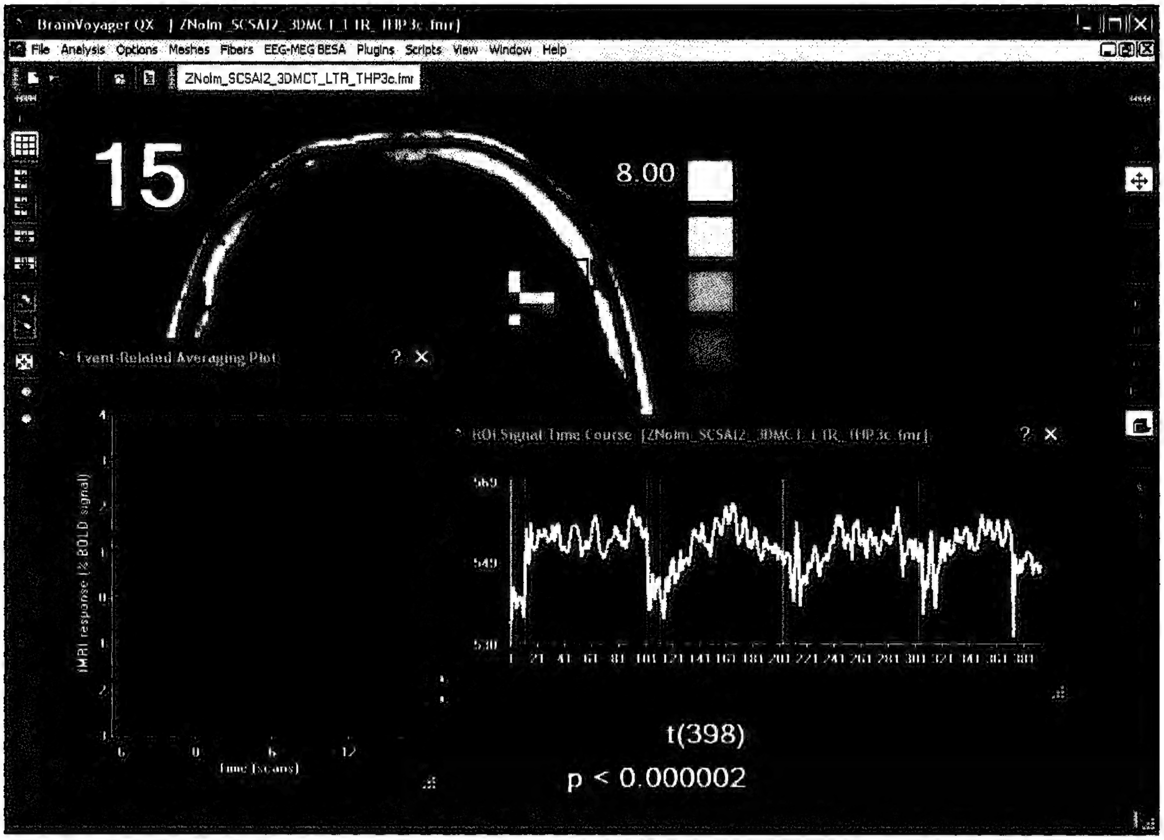


Image #5

DLPFC (BA 45, 46), Occipital (BA 17, 18) and Occipito-temporal (BA 37, 39)

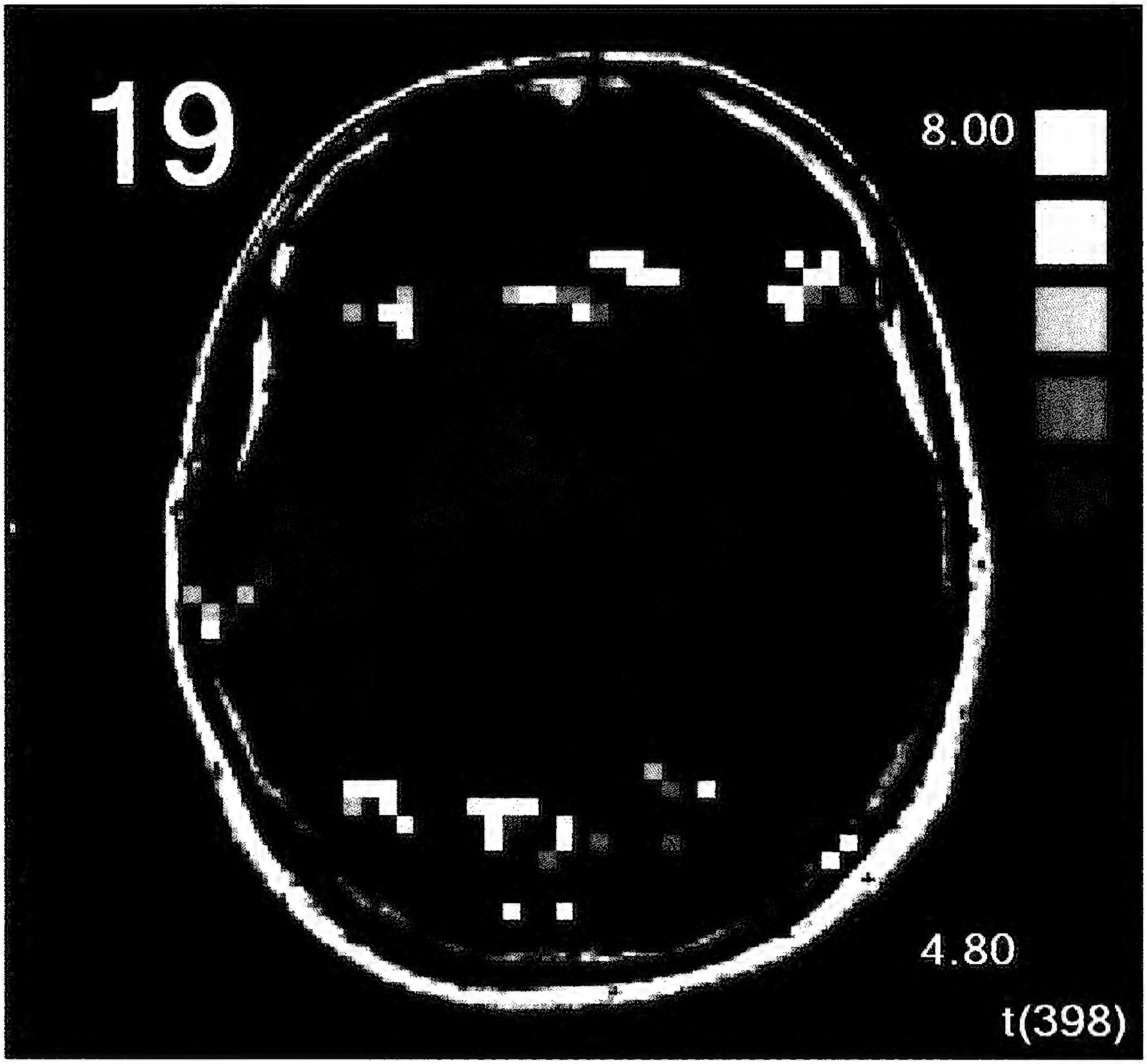


Image #6

Medial pre-frontal cortex and anterior cingulate gyrus (BA 10, 24, 32)

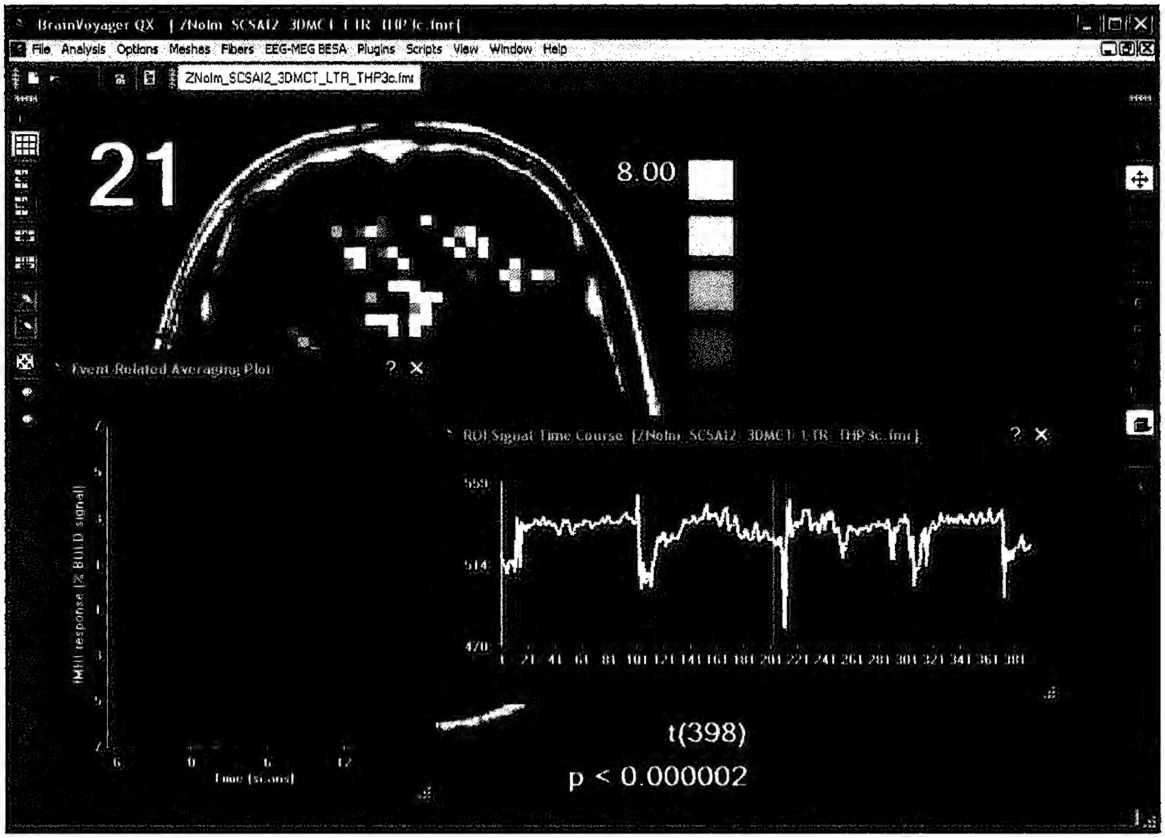


Image #7

Medial and ventral-medial pre-frontal cortex (BA 10,11).

Higher visual areas in the occipital cortex and the occipito-temporal cortex

(BA 18, 19, 37).

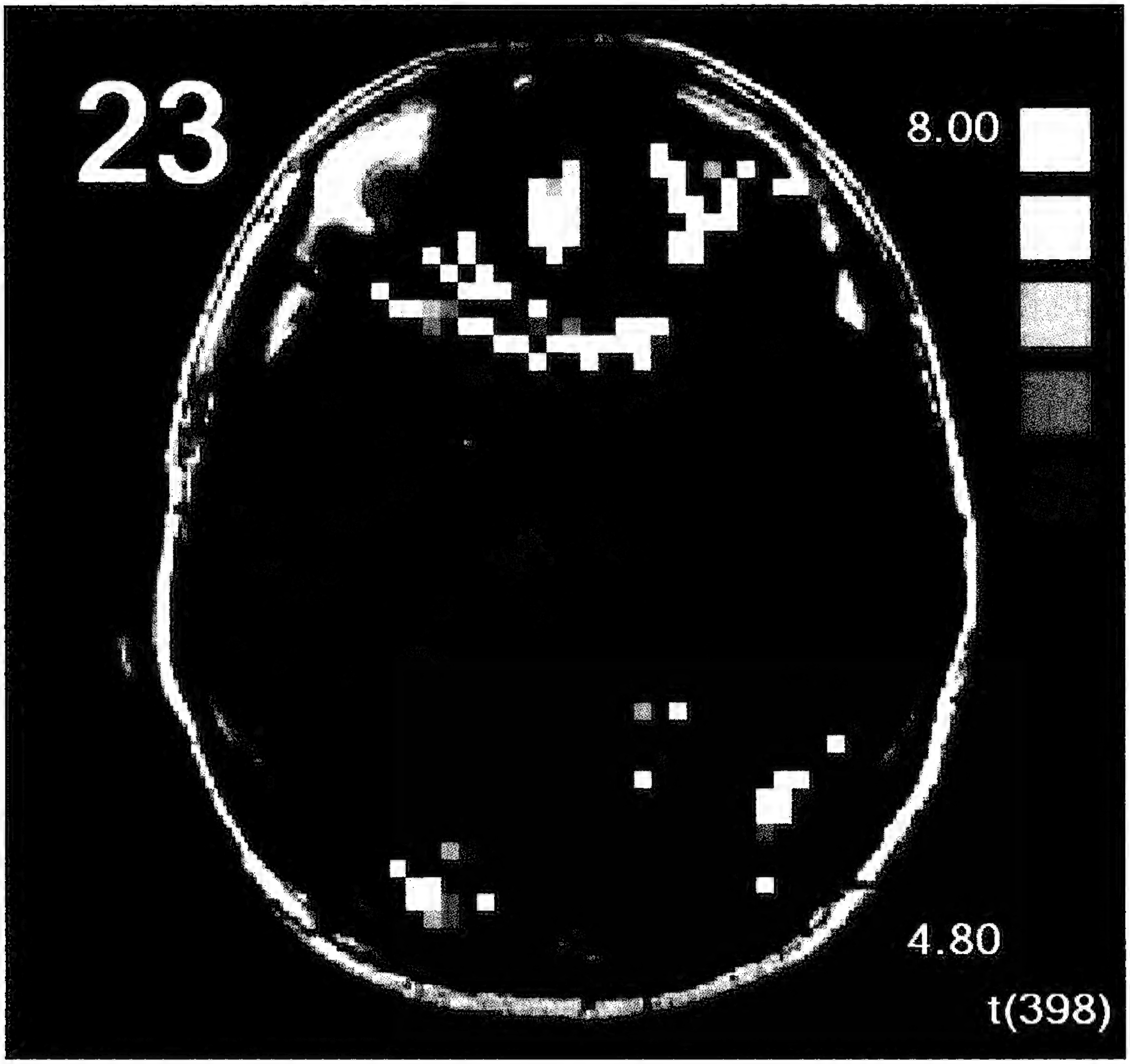
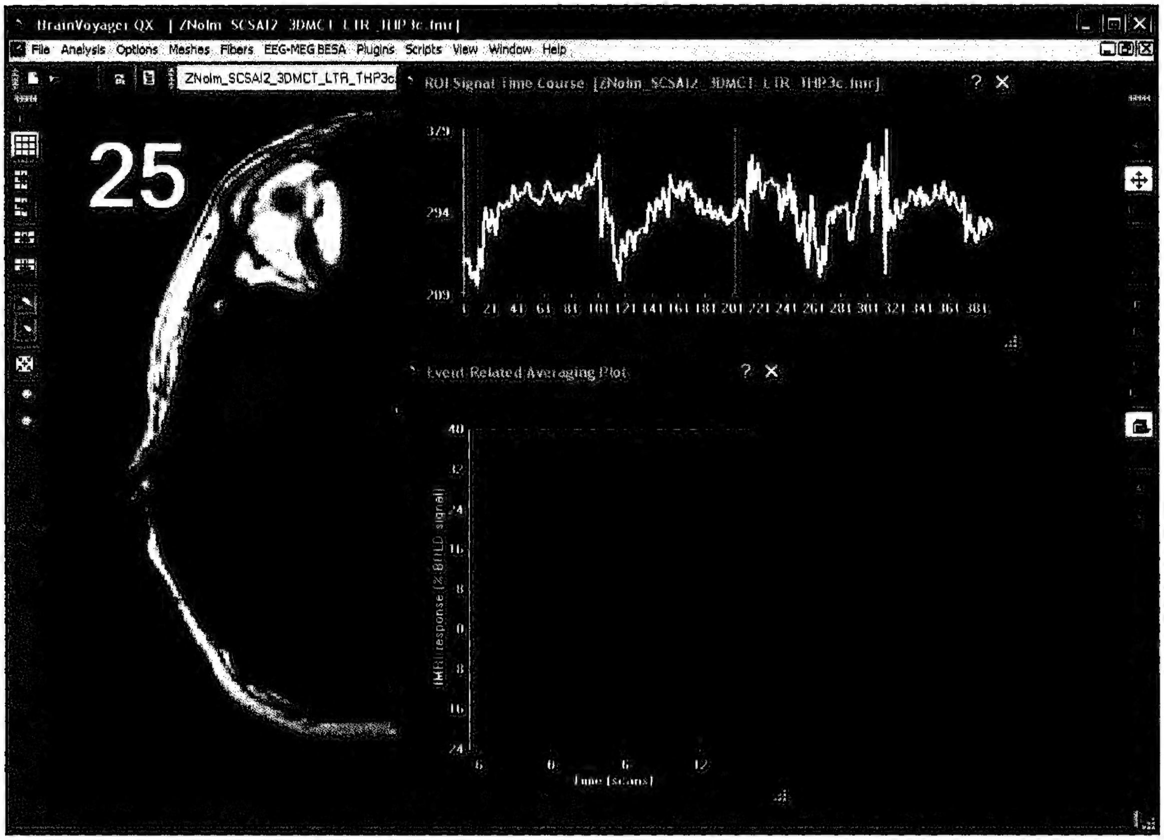


Image #8

Meditation minus counting in the inferior occipito-temporal cortex (BA 37)



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